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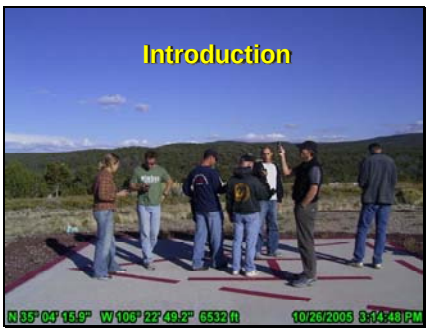
Chapter 1 – Introduction to GPS

Slide 1



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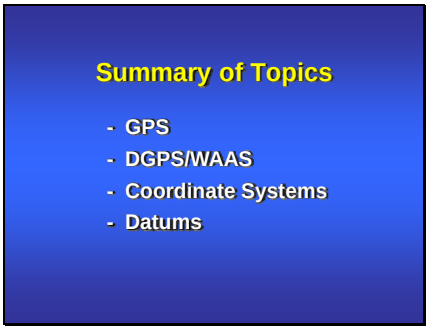

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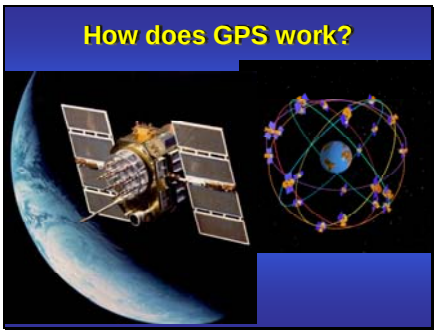
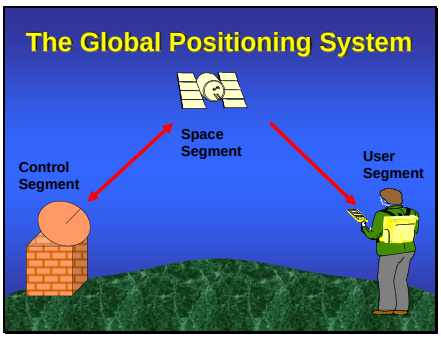


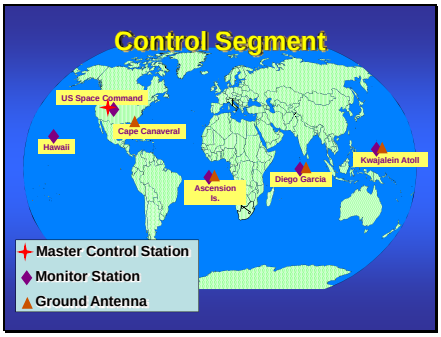
There are currently more than 30 satellites launched by USAF

Slide 4



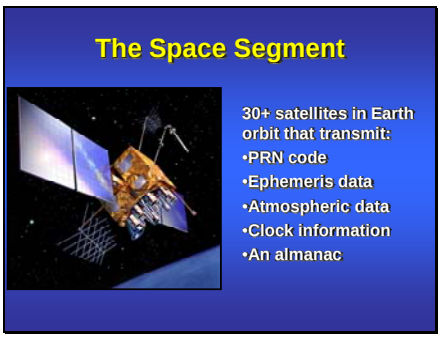
3 segments.
1. Control segment manages the satellites – there are no more slides about this segment
2. The space segment is the satellites – more slides
3. User segment
By January 17, 1994, a complete constellation of 24 satellites was in orbit.
July 17, 1995, reached Full Operational Capability

Slide 5



Control Segment
The Master Control Station or MCS (also known as the Consolidated Satellite Operations Center) is located at the US Air Force Space Command Center at Schriever Air Force Base (formerly Falcon AFB) in Colorado Springs, Colorado. It's responsible for satellite control and overall system operations. The Control segment is made up of a Master Control Station (MCS), five monitor stations, and three ground antennas (plus a reserve antenna at Cape Canaveral used primarily for pre-launch satellite testing) used to uplink data to the satellites. Monitor Stations continuously receive GPS satellite transmissions, and relay this information in real time to the Master Control Station in Colorado. The user segment also receives these same transmissions.
The MCS uplinks data to GPS satellites which includes:
-Clock-correction factors
-Almanac
-Ephemeris data

Slide 6



The Space Segment consists of 24 or more GPS satellites circling the Earth in six orbital planes inclined at 55 degrees to the equator. Satellites orbit the Earth at an altitude of about 12,000 miles and complete an Earth orbit every twelve hours. With an orbital speed of about 1.8 miles per second, they make a horizon-to-horizon transit in about 2 hours.

GPS satellites currently transmit on two frequencies, and a third is being deployed. Frequency "L1" is used by consumer- and mapping-grade GPS units, and "L2" serves the survey-grade GPS units. The Precise Positioning Service (PPS) receivers use an encrypted code on L1 and some PPS units use both L1 and L2The signal broadcast to GPS receivers on L1 includes:

•**PRN code** (a complex code unique to each satellite) permits receivers to calculate their distance from each satellite.

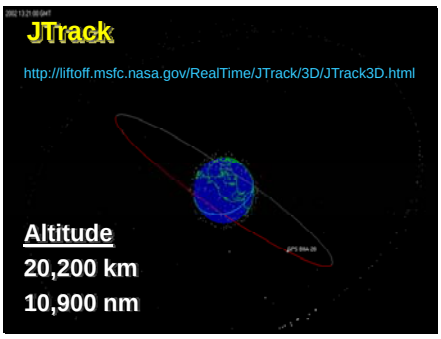
•**Ephemeris data** provide extremely accurate orbital information unique to each satellite.

•**Atmospheric data** help receivers account for some portion of signal delay caused by the atmosphere.

•**Clock information** defines the exact time of satellite signal transmission.

•**An almanac** is a constellation-wide schedule of GPS satellite positions, and their states of health. Receivers automatically download, and store, a fresh almanac whenever receiving a signal. The stored almanac permits rapid signal acquisition at next use because the receiver will already "know" the scheduled location and health of GPS satellites. An almanac may become obsolete if a receiver isn't used for 30 days, or is moved more than 300 miles while not receiving a signal.

Slide 7



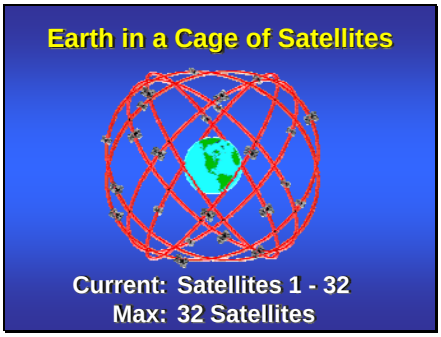
Here's one satellite going around the earth. This provides a sense of the satellites orbit.

All the dots are satellites. Click on one and the orbit and name appears. It's real time. Can twist and turn the globe around for perspective that matches your location.

satellites are about 12,500 statute miles ≈ 12,000
earth's diameter 8,000 miles

10,988 nautical miles (12,645 statute miles)

Slide 8



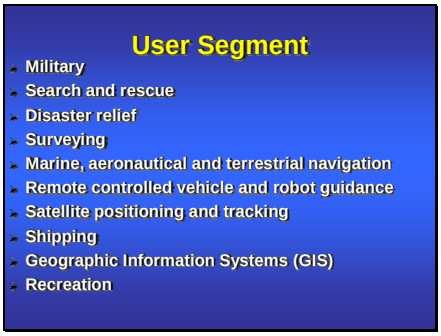
Here's what all the satellites look like going around the earth

Although the system was designed to be fully functional at 24, we have 32 possible functioning satellites. On any given day one or more may be offline for maintenance.

System cannot broadcast more than 32. So if new satellite becomes functional, then an old one must be turned off.

For complete list of satellites visit Navcen's GPS Constellation Active Nanu Status: http://www.navcen.uscg.gov/navinfo/Gps/ActiveNanu.aspx

Slide 9



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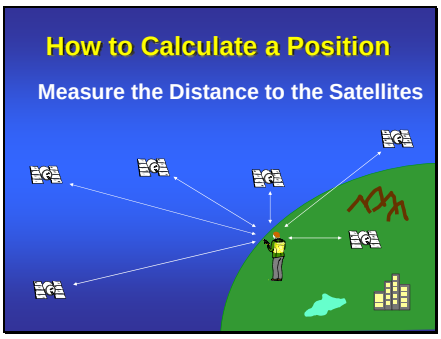
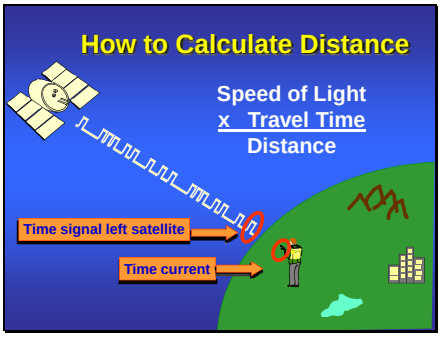


The question is what is the minimum number of satellites required for the GPS receiver to calculate its location in terms of latitude, longitude and elevation?

Remember how the receiver determines its location - it measures the distance to a number of satellites. There's only one place we can be based on all of these measurements.

Slide 11



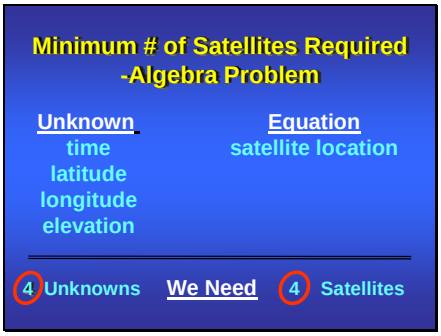
However, the distance is not measured directly, it's also calculated. That calculation is based on measuring time.

Clocks inside the GPS receiver are very inaccurate compared to the clocks inside the satellite. So essentially we have another unknown.

All together we have 4 unknowns: time, latitude, longitude and elevation.

In 1 microsecond the signal travels about 300 meters.

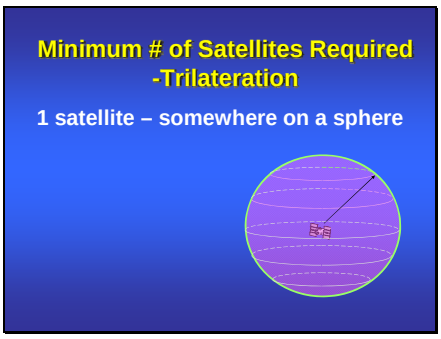
Slide 12



Now, think of solving for all of these unknowns as an algebra problem. In other words we need one equation to solve for one unknown, 2 equations for 2 unknowns, etc. So if you think of each satellite as providing an equation, then that means we need a minimum of 4 satellites to calculate the latitude, longitude and elevation of our position.

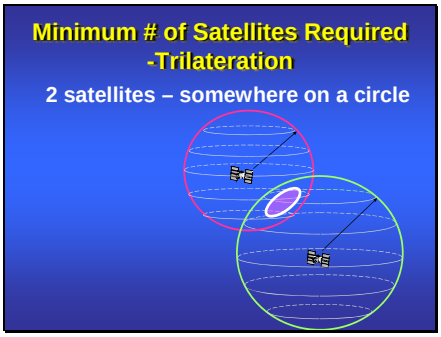
Please note that I use 1st, 2nd, 3rd as a way of counting satellites. I do not mean that if you had only 2 satellites you would at least have determined your latitude.

Slide 13



An alternative way of looking at this is triangulation – actually in our case it's trilateration

Slide 14



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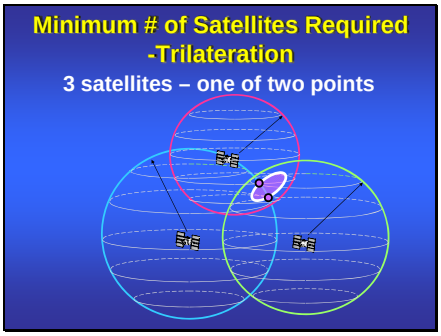
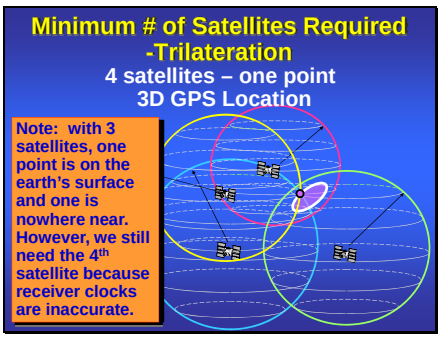


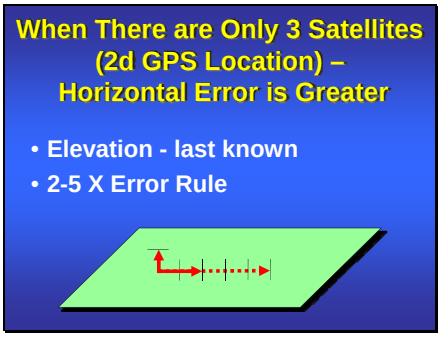
Slide 16



So in order to calculate a position, the receiver needs a minimum of 4 satellites.

This is also called a 3D position because the receiver has calculated the lat, long, and elevation. On the GPS receiver it displays 3D GPS Location.

Slide 17

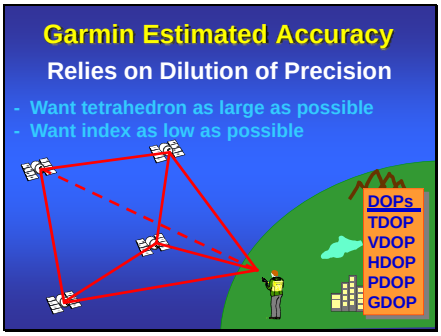


Garmin calls it 2D GPS Location, elevation cannot be calculated, but elevation must be part of the equation, therefore, receiver uses the last value it had for elevation.

2-5x rule: for every unit of error in the vertical, there is a 2-5x error in the horizontal.

Example: if the vertical is off by 10 feet, then the horizontal could be off by 20-50 feet.

Slide 18

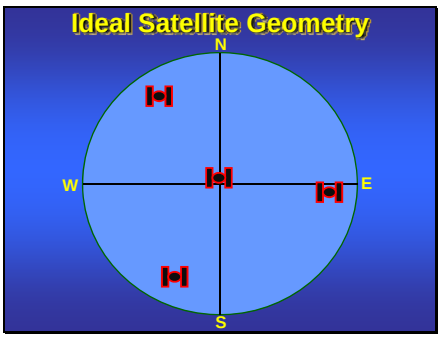


Now, we know we need at least 4 satellites. Does it matter <u>where</u> the satellites are in the sky? Yes.
There are lots of DOPs. In this case we are using PDOP as a measure of how spread out the satellites are.

If all my satellites are clumped together, there's nothing to offset the error in another direction. So ideally, I want 1 satellite overhead and 3 arranged around the horizon about 120 degrees apart.

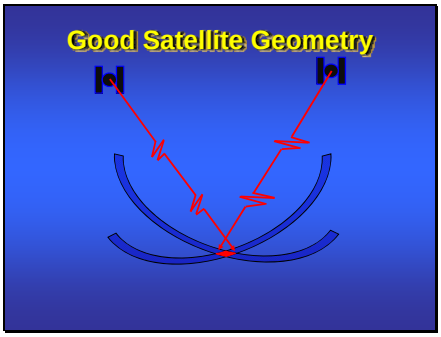
There are no satellites under the earth to offset the error that's in the direction of all the satellites above the earth. So rule of thumb is vertical error is 1.5 to 2 times the error of the horizontal error.

Slide 19



In the diagram, the outer ring of the circle represents the Earth's horizon. The center of the cross hair represents the sky directly above the GPS receiver. The satellite configuration shown is considered optimal for providing the best 3D positioning because any horizontal error from one direction will be offset by the opposing satellites. The fourth satellite directly overhead improves vertical accuracy.

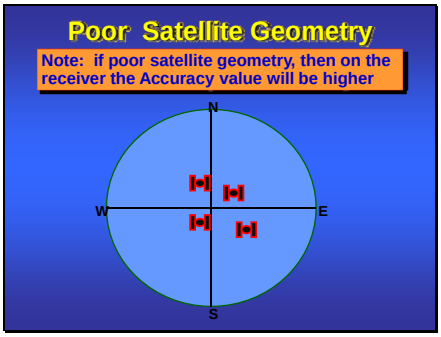
Slide 20



The area where all four calculated pseudo-ranges intersect will be much smaller, providing a more precise position (as shown). The farther apart the satellites are from each other the smaller the smaller area of position uncertainty will be (shown by the diamond be in this diagram), resulting in low PDOP.

If at all possible a GPS receiver will choose four satellites spread out across the sky rather than four satellites bunched close together in one quadrant of the sky. But it should be noted that many receiver types (Garmin included) always try to provide a position, even a poor position, regardless of satellite geometry. The reasoning is that any GPS position information provided by the receiver is better than no position information.

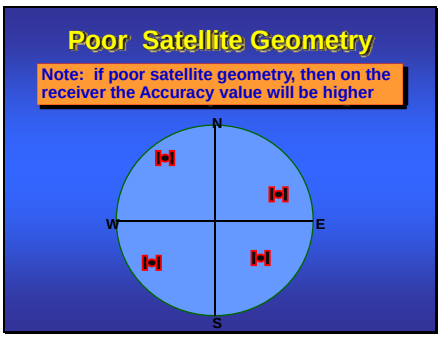
Slide 21



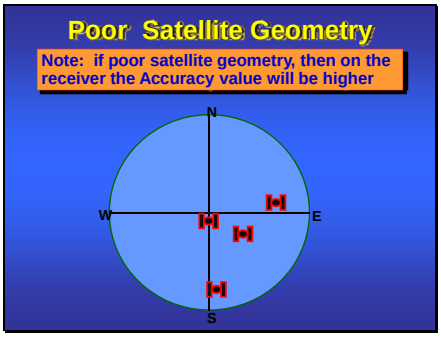
Poor Satellite Geometry

The locations of satellites in relation to each other in space at any given time can affect the quality of a GPS receiver's position fix. If all satellites acquired by a receiver are bunched closely together in one quadrant of the sky can also result in poor triangulation measurements (and a high PDOP). Topography on the ground also affects satellite geometry. A receiver inside a vehicle, near tall buildings, under dense canopy, or in mountainous terrain can be affected by blocked signals. GPS receivers require clear line of sight to every satellite or else signal will be lost.

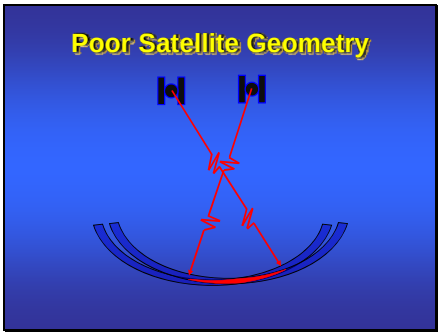
Slide 22



Slide 23

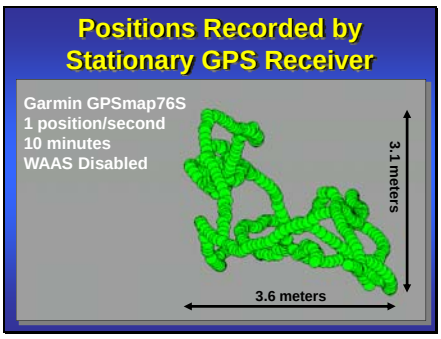


Slide 24



Most of the time there are more satellites available than a GPS receiver needs to triangulate a good position fix, so the receiver can pick satellites which will provide the best geometry to provide a precise position. However, if a receiver happens to acquire satellites that are spaced closely together in the sky will result is a larger area of position uncertainty around the receiver. Add several more satellites with the same tight pattern, and the resulting position error will be very high.

Slide 25



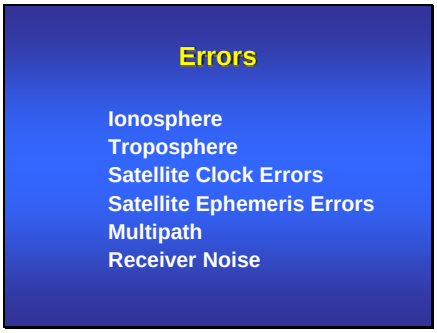
The positions illustrated were captured by a stationary GPS receiver. The receiver never moved, but the positions it reported during a 10-minute period had a maximum spread of over 4.4 meters (on the diagonal). Furthermore, repeating the process would result in a different set of positions.

GPS positions aren't absolute. Even when a receiver is stationary, its calculated position will fluctuate as a result of:

- Constantly shifting satellite arrangement
- Sophistication of the receiver's antenna
- Consistency of local conditions

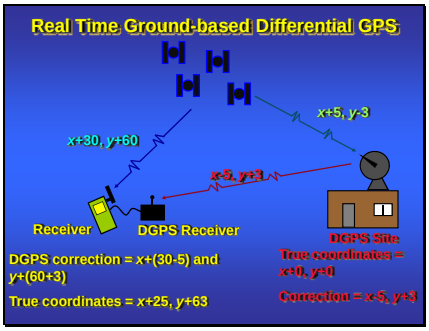
Since GPS positions aren't absolute, a receiver may have difficulty navigating back to the exact position of a previously established waypoint. It should, however, get you pretty close.

Slide 26



Anything that affects the length of time it takes the signal to reach the GPS antenna will add to the error in the location of a position. We know there are charged particles in the ionosphere and weather in the troposphere. We know that the satellites keep precise time, only the earth doesn't (like the leap seconds that are added routinely), and the satellites' locations need to be updated. Then there's the bouncing around of multipath and how well the GPS is engineered to reduce noise.

Slide 27



Real Time Differential GPS

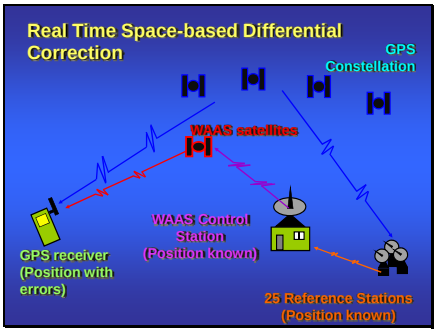
(This is an example of <u>real time</u> DGPS, and not a representation of differential correction done in the office on a computer using software such as Trimble's Pathfinder Office.)

Real-time DGPS employs a second, stationary GPS receiver at a precisely measured spot (usually established through traditional survey methods). This receiver can correct many errors found in the GPS signals, including atmospheric distortion, orbital anomalies, and other errors. A DGPS station is able to do this because its processor already knows its precise location, and can easily determine the amount of error provided by the GPS

signals by comparing its known location with the erroneous position data provided by the GPS.
DGPS corrects or reduces the effects of:
- Orbital errors
- Atmospheric distortion
- Selective Availability
- Satellite clock errors

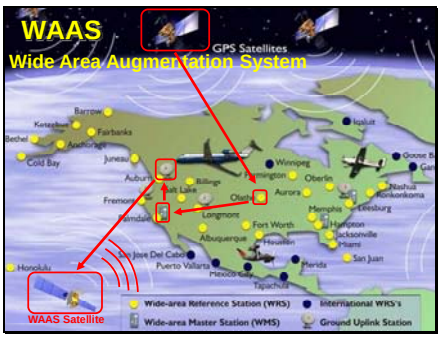
DGPS cannot correct for GPS receiver noise in the user's receiver, multipath interference, and user mistakes. In order for DGPS to work properly, both the user's receiver and the DGPS station receiver must be accessing the same satellite signals at the same time. This requires that the user's receiver not be more than 300 miles from the DGPS station (100 miles or less is considered optimum). In the example, the DGPS station receives GPS signals telling the station that its location is x+5, y-3. But the station already knows that its true location is x+0, and y+0. So it calculates a correction of x-5, y+3, and transmits this correction out to the field on its own frequency. The DGPS receiver in the field uses this correction factor to update the same GPS radio signals it's receiving. Here the GPS receiver triangulates its position with GPS as x+30, and y+60. The DGPS receiver provides the correction factor to the GPS receiver's processor, which calculates its correct position at x+25, y+63. The user can generally get accurate position fixes within a few meters or less using DGPS technology.

Slide 28



The Wide Area Augmentation System (WAAS) is designed to enhance GPS positioning over the United States, as well as portions of Mexico and Canada. Unlike GPS, which is funded and maintained by the Department of Defense, WAAS is funded by the Department of Transportation.

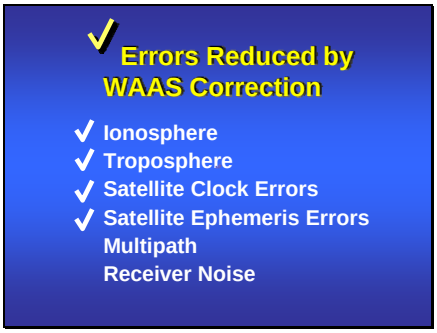
Slide 29



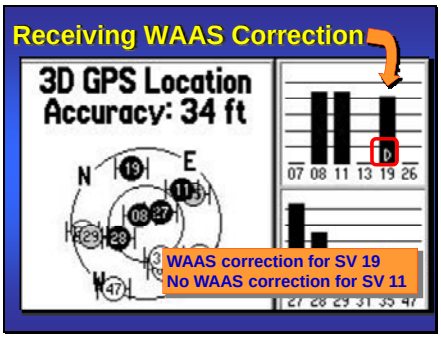
WAAS works on the same principle as DGPS, except that timing corrections are broadcast to geosynchronous WAAS satellites for re-broadcast to GPS receivers in the field.

GPS signals are received by Reference Stations. The reference stations calculate the error, and send it to the Master Stations. The Master Stations forward the corrections to the uplink stations. The uplink stations transmit the corrections to the WAAS satellites. The WAAS satellites send signals containing the corrections back to earth. GPS receivers calculate their location based on the GPS signals, and apply corrections to that calculation based on the corrections in the WAAS signal.

Slide 30

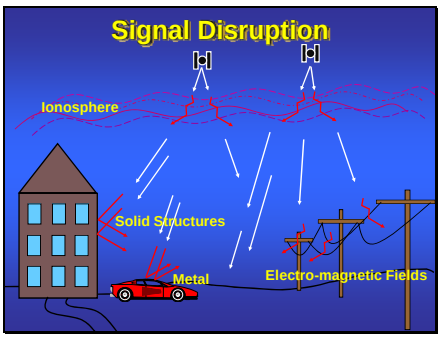


Slide 31

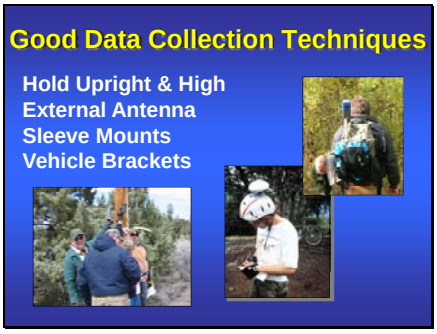


WAAS improves accuracy of autonomous GPS positions but relies on direct line of sight to one of two geostationary satellites. Ensure GPS is held upright (use bracket in aircraft or external antenna) to maximize view of southern sky for highest accuracies.

Slide 32

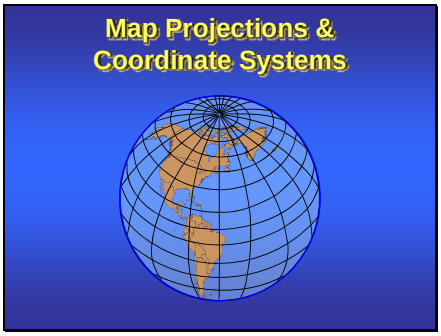


Slide 33

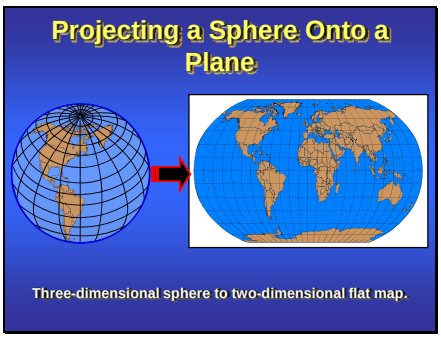


The **human body** can cause signal interference. Holding a GPS receiver close to the body can block some satellite signals and hinder accurate positioning. If a GPS receiver must be hand held without benefit of an external antenna, facing to the south can help to alleviate some signal blockage because the majority of GPS satellites are oriented more in the southern sky. **Errors in GPS are cumulative**, and are compounded by position dilution of precision (PDOP). It is the user's responsibility to insure the accuracy of the data being collected with the GPS.

Slide 34



Slide 35



Projecting a Sphere Onto a Plane

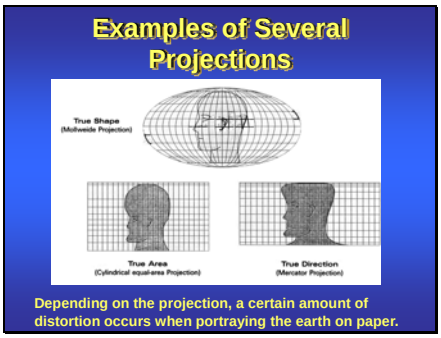
The earth is a three-dimensional sphere that can be portrayed on two-dimensional paper maps using a process called "projection." Whenever a three-dimensional object (such as a sphere) is projected onto a flat surface a certain amount of distortion occurs. This is because displaying three-dimensional objects in two-dimensional form is very difficult to do without introducing some distortion.

To demonstrate this, try peeling an orange, keeping the rind in one piece. Then press the rind onto a flat surface. Notice how the rind "splays" outward when pressed flat? It loses its original shape and dimensions. The same thing occurs when projecting the earth onto flat maps. This is one reason why map projections generally tend to be regional in scope, and cover only a portion of the earth's surface.

Every projection presents some form of distortion. Map distortion can affect **shape**, **area**, **distance**, and **direction**. Any one form of distortion, or a combination of all four, may be present in a map projection. Mapmakers over the years have created many different projections to suit their particular cartographic needs. For example, a mapmaker creating an road map will probably not want to select a projection that distorts distance and direction.

The next slide shows examples of distortion among several projections.

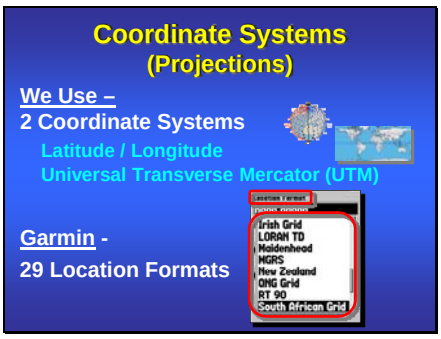
Slide 36



Examples of Several Projections

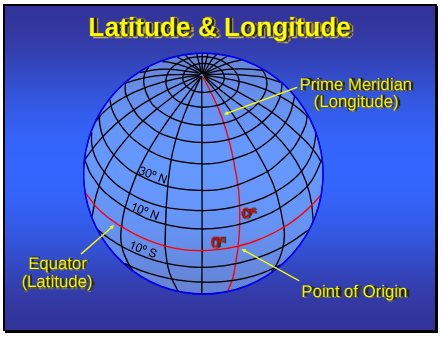
Each projection incorporates its own unique distortion. Forms of map distortion include **shape**, **area**, **distance**, and **direction**. Using the peeled orange analogy again, with virtually all projections distortion increases the further away from the projection's point of origin. If the peeled orange is pressed flat, the center of the peel will exhibit the least amount of shape and linear distortion, while the outer edges will exhibit the greatest distortion. The same is true for map projections.

Slide 37



Garmin doesn't list coordinate systems or projections – they list Location Formats, which is a combination of different coordinate systems and different ways of expressing one coordinate system. Coordinate systems assign a unique "address" to every point on Earth. Coordinates are expressed relative to a datum.

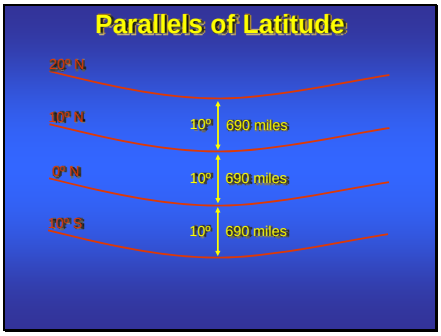
Slide 38



Latitude & Longitude

The point of origin for latitude and longitude on the Earth's surface is where the Prime Meridian and the equator intersect. Geographically that point is just west of Africa in the South Atlantic Ocean. Lines of latitude (known as "parallels") slice through the Earth horizontally. Lines of longitude (known as "meridians") slice through the Earth vertically.

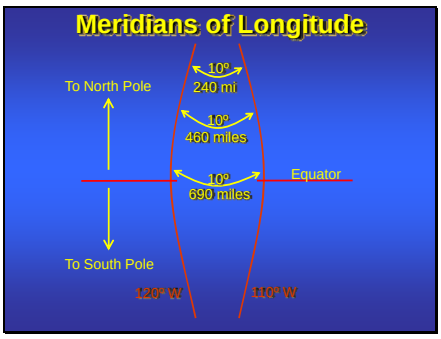
Slide 39



Parallels of Latitude

The distance between each degree of latitude does not change, regardless of where it lies in relation to the equator. This differs from longitude where lines converge as they approach the North and South Poles.

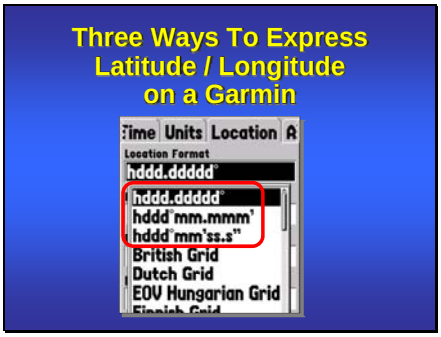
Slide 40



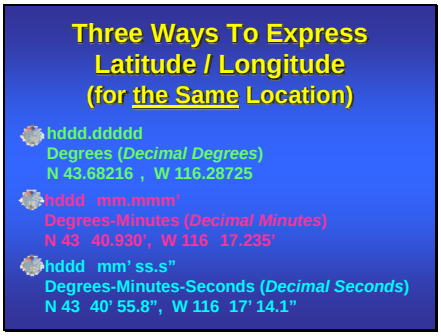
Meridians of Longitude

Longitude lines (meridians) run north to south, but partition the Earth into east and west halves. Unlike latitude, the distance between each degree of longitude narrows as the distance away from the equator increases.

Slide 41



Slide 42



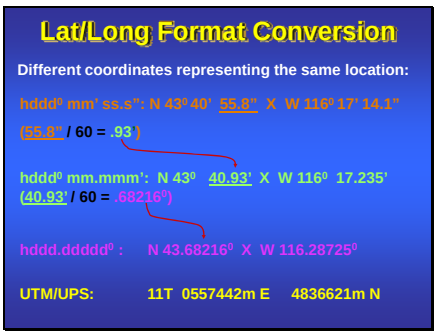
Here is what we mean by formats.

Latitude and longitude can be expressed in three different formats. Though their formats differ, these coordinates are equivalent.

The conversion works like this:

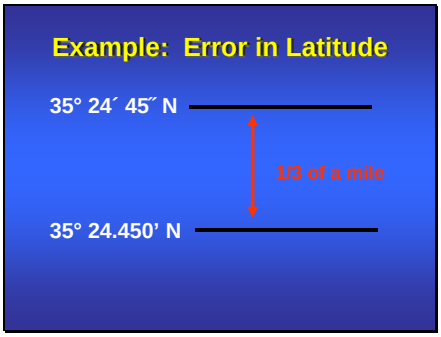
- To convert seconds to decimal minutes, divide the seconds by 60 to get decimal minutes.
- To convert minutes to decimal degrees, divide the minutes by 60 to get decimal degrees.

Slide 43



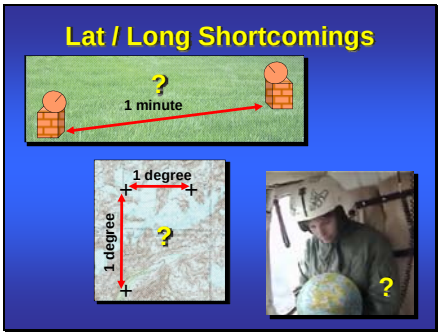
We will be doing an exercise in class to practice these conversions and you will see how simple the math is for lat long format!

Slide 44



These two latitudes are not the same, although someone might carelessly place a decimal thinking it's the same.

Slide 45

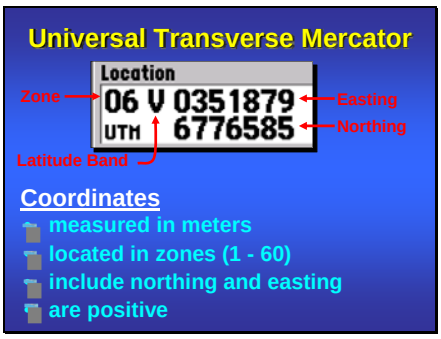


It's hard to relate to a distance in terms of degrees, minutes and seconds. I have a sense of what a foot or meter means. I don't have a sense of what a minute is (By the way, it's 1.2 statute mile at the equator).

Furthermore the distance covered by 1 degree of latitude is the same as the distance covered by 1 degree of longitude only at the equator.

And it's really hard to pack a globe with you when you need a map.

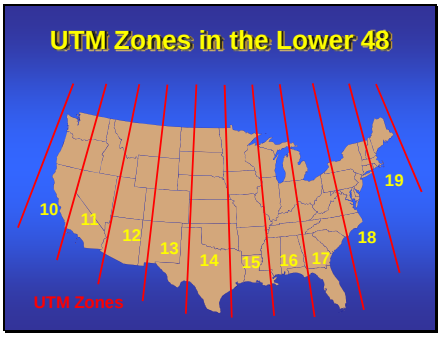
Slide 46



UTM uses meters – something we understand.

UTM provides a way of taking the 3-dimensional sphere that's inconvenient for traveling and flattening it onto a 2-dimensional piece of paper that travels well. When a sphere is flattened there is distortion.
1. UTM minimizes the distortion by creating 60 zones. In our example the zone number is 6.
2. Remember on the globe, 1 degree of latitude does not cover the same distance on the earth as 1 degree of longitude when you are away from the equator? The same thing happens when you look at longitude on paper – 1 degree of latitude will not cover the same distance on the paper as 1 degree of longitude. Well, on the UTM grid we can measure 1 meter and it will cover the same distance on the paper no matter what direction in which you chose to measure.
The coordinates are called easting and northing because they are only to the east of a starting point and only to the north of a starting point which means ….all the coordinate values are only positive. In the GIS world of lat/long, north is positive and south is negative, east is positive, west is negative. In the UTM world we aren't negative.

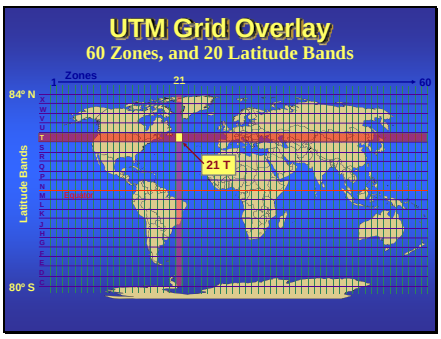
Slide 47



UTM Zones Covering Contiguous U.S.

The continental United States lies within ten UTM zones.

Slide 48



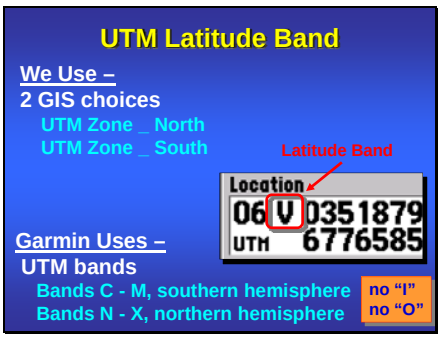
Universal Transverse Mercator

Note: The grid shown in the example is not drawn to scale.

There are sixty UTM zones, running north-south, cover all of the earth, beginning with zone 1 located at 180º W longitude. Twenty latitude bands, running east-west, cover most of the earth from 80º S latitude to 84º N latitude. The polar regions are covered by the Universal Polar Stereographic coordinate system, which is based on the UTM system. Notice that the letters “I” and “O” are not used to designate a latitude band. This is to prevent confusion with the numbers 1 and 0. The Equator separates latitude bands N (north of the Equator), and M (south of the Equator). If a GPS receiver is showing a position with a latitude band letter of C through M, then it thinks it’s in the southern hemisphere If the latitude band letter shown on a GPS receiver display is N through X then the receiver thinks it’s position is in the northern hemisphere. Either hemisphere could have exactly the same easting and northing coordinates representing two different locations (one in each hemisphere) within the same zone.

Zones and latitude bands make up 1,200 unique grid rectangles in the UTM grid system. A UTM zone is 6° wide (remember, it’s based on longitude) and extends from 80° south latitude to 84° north latitude. By knowing the correct zone number and latitude band letter, you can narrow your location from the entire surface of the earth down to a rectangle 6° x 8°, as shown in the example above with “21T.” The easting and northing numbers refine the position to a single point somewhere inside that rectangle.

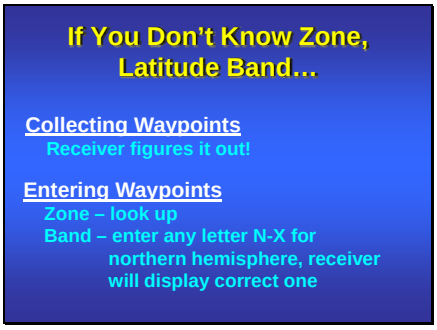
Slide 49



In the GIS world each UTM zone comes as a north or south choice.

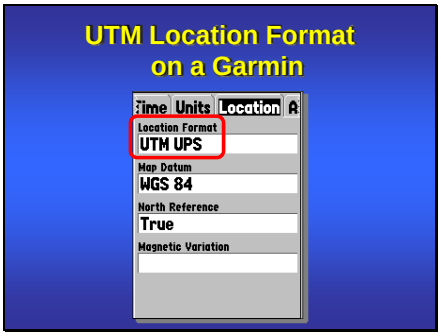
Gamin displays the UTM latitude band

Slide 50



If you don't know the UTM zone and latitude band, then there are 2 situations – one when you need to enter the coordinates on the receiver and the other when you are collecting a waypoint in the field.

Slide 51

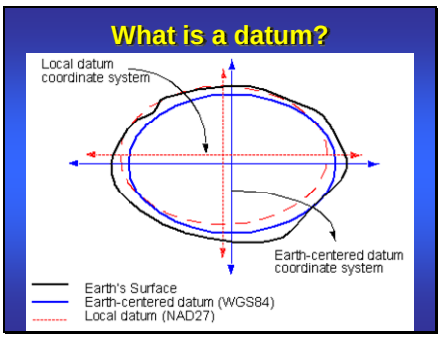


UTM is Universal Transverse Mercator
UPS is Universal Polar Stereographic

Actually, they are 2 separate systems. UPS covers the North and South Pole areas, and UTM covers everything else.

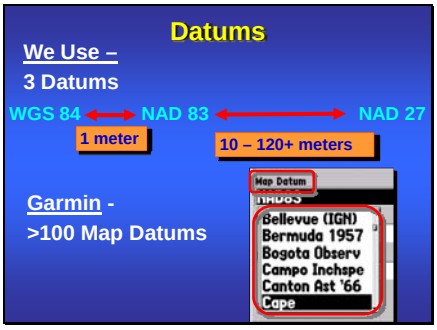
Garmin, of course, handles it their own way and combines them on the tab.

Slide 52



Coordinates are expressed relative to a datum, and that a datum can be thought of as the point-of-origin for a map's coordinate values, just like the 0,0 point on an XY graph. Furthermore, each datum will have a different point-of-origin because it is based on a different spheroid, or "model" of Earth's size and shape.

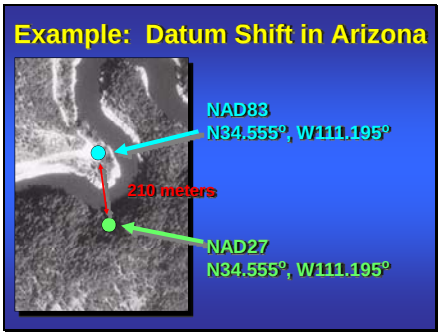
Slide 53



NAD 27 is a local datum for North America and has its origin in on the surface of the earth - Kansas. More recently, NAD 83 & WGS 84 are earth centered datums and used satellite measurements for determining center of the earth and spheroid shape.

The difference between NAD83 and NAD27 is about 10-120 meters unprojected. Once projected, that distance is can swell a lot.

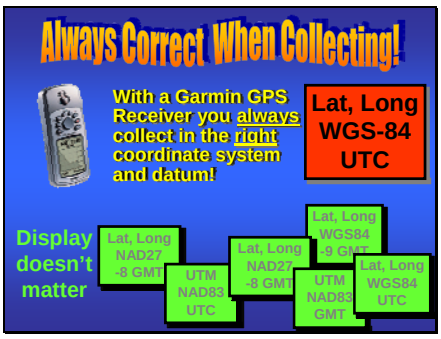
Slide 54



Switching from one datum to another, whether in a GPS receiver or on a map, results in different coordinate values (known as a "datum shift") for every feature. In other words, when a change of datum occurs, the coordinate system grid (the map's "graph paper") shifts slightly to match the new datum's point-of-origin, while Earth's features remain stationary. Each point on Earth's surface will have a different set of coordinates depending on which datum those points are referenced to.

Unrecognized datum shift may have consequences if the mis-applied coordinates refer to a safety zone, drop point, medevac point, helispot, or other critical feature.

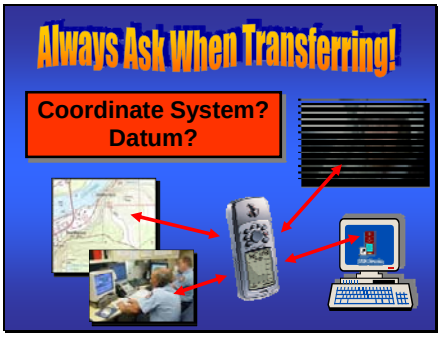
Slide 55



To alleviate datum mis-match issues, users should follow these guidelines:

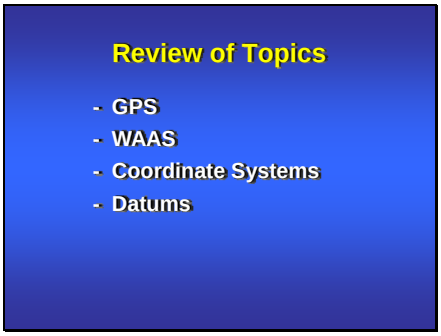
- Verify which datum and coordinate system are officially sanctioned, and use them.
- When receiving coordinates, always verify which datum they are referenced to.
- When plotting coordinates from a map, use the map's legend to determine datum.
- When passing GPS coordinates on to other users, always provide datum.
- When manually entering coordinates on a GPS receiver, set the receiver's map datum and location format to match those of the coordinates.

Slide 56



Remember, if it's lat/long, which format? and IF UTM, what zone?
Fed Datum Standard is NAD83, Pilots work in WGS84. If we had to break the Datum shift issue into two areas where it matters most, its in the Field and in the GIS.
1. In the field when communicating between GPS users and when communicating or transferring data between GPS and paper maps. The classic example here is the dispatcher is in one datum and you, the user is in another datum.
2. In the GIS, after the data is stored and transferred into a Geographic Information system like ArcGIS.

Slide 57

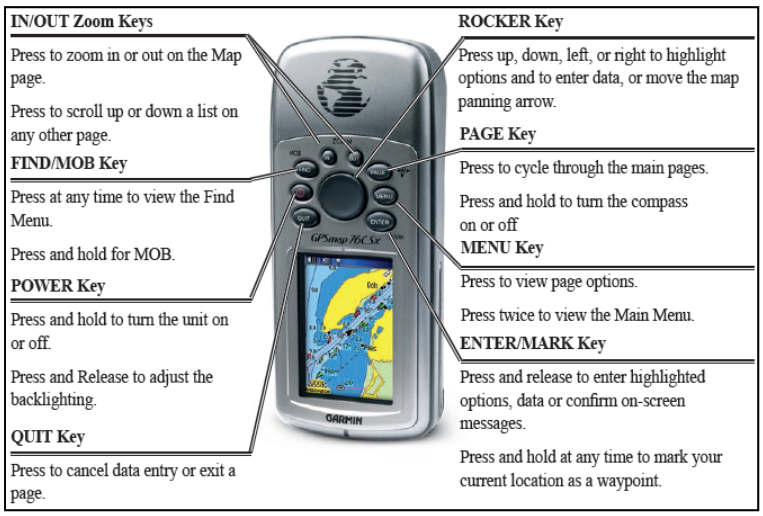


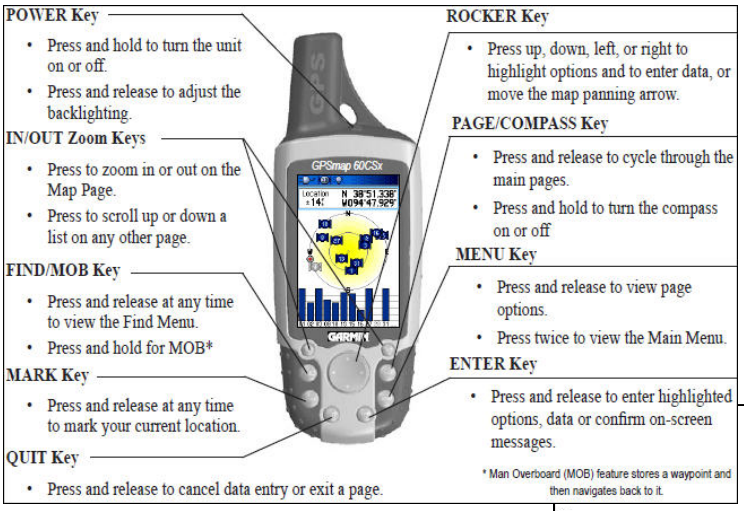
Chapter 2 - Garmin GPS Receivers

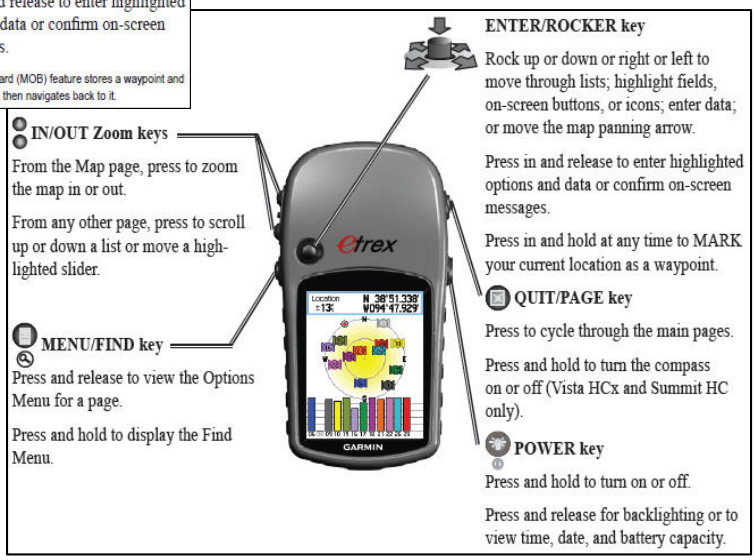
2.1 Keypad layout

Users press buttons, or “keys”, to operate the receiver.

The layout and a brief description of keypad configurations for the **GPSMAP 76CSx, GPSMAP 60CSx** and the **eTrex HC series** are illustrated below.





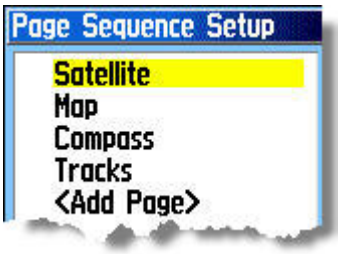


2.2 Receiver pages

Receiver functionality is facilitated through a series of “pages”. Each page conveys a certain kind of information, or helps the user perform specific tasks.

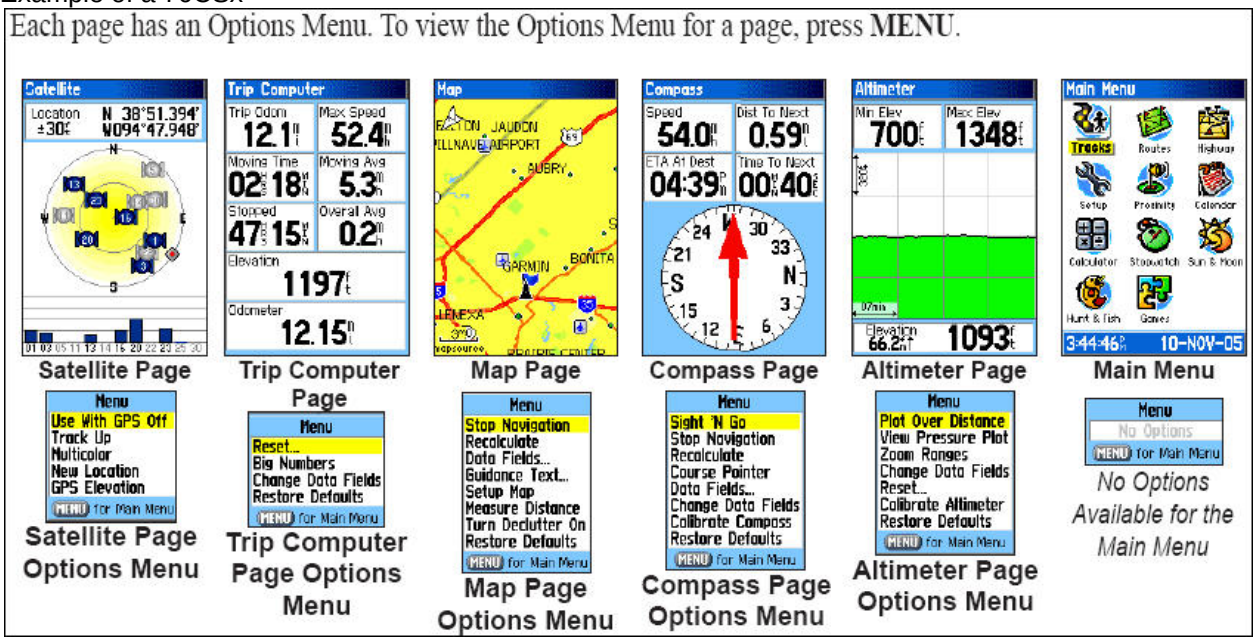
The **Satellite**, **Trip Computer**, **Map**, **Compass**, **Altimeter**, and **Main Menu** pages are examples of the roughly 20 pages available on many Garmin receivers.

Users can cycle through the receiver’s page sequence by repeatedly pressing the **Page** key.
Users can customize the receiver’s page sequence to their liking by pressing **Menu – Menu – Setup - Page Seq**, selecting an item, and pressing **Enter** to **Move**, **Insert**, **Remove**, or **Add** pages, as illustrated at right.

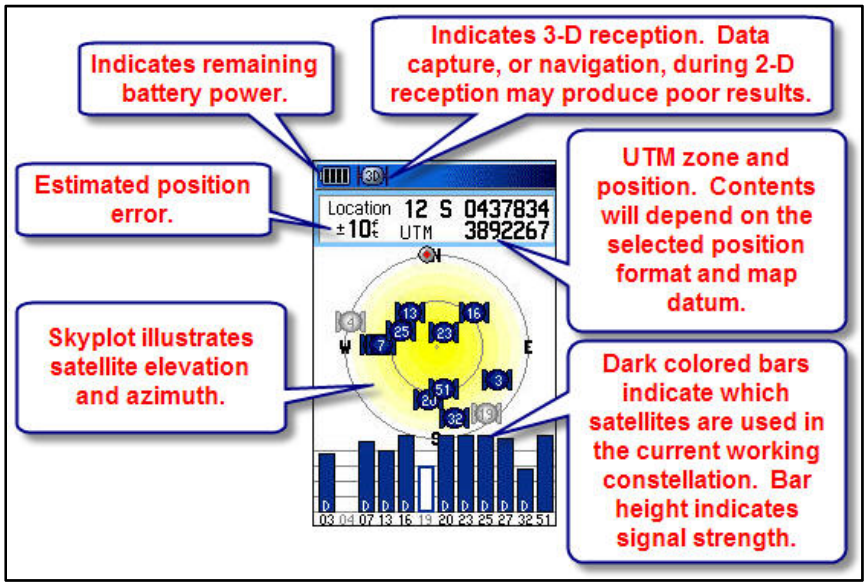


Each page has a series of options that can be activated by pressing **Menu** while viewing that page.

Many pages can be configured to display several user-selected data fields.
To do so, press **Menu** while viewing a page, select **Data Fields…** or **Change Data Fields**, and press **Enter**.
Example of a 76CSx



2.3 Satellite page - Example



The satellite page conveys the current status of GPS positioning. It contains these elements.

- The battery power icon indicates the amount of AA battery power remaining. This icon is visible on every page.
- The 3D icon indicates that 3-D positions are being calculated. Data capture, or navigation, during 2-D reception may produce poor results. This icon is also visible on every page.
- The estimated position error is a general indicator of position quality. It is not an exact measure of position accuracy.
- A skyplot illustrates satellite elevation and azimuth. Well distributed satellites tend to improve position quality.
- Dark colored bars indicate which satellites are being used in the receiver's current working constellation. Bar height is an index of signal strength. A "D" indicated differentially corrected (when WAAS enabled).
- Contents of the **Location** field will depend on the receiver's currently selected **Position Format** and **Map Datum** settings. In this example, the UTM zone and coordinates are shown.

2.4 Main Menu and Setup pages

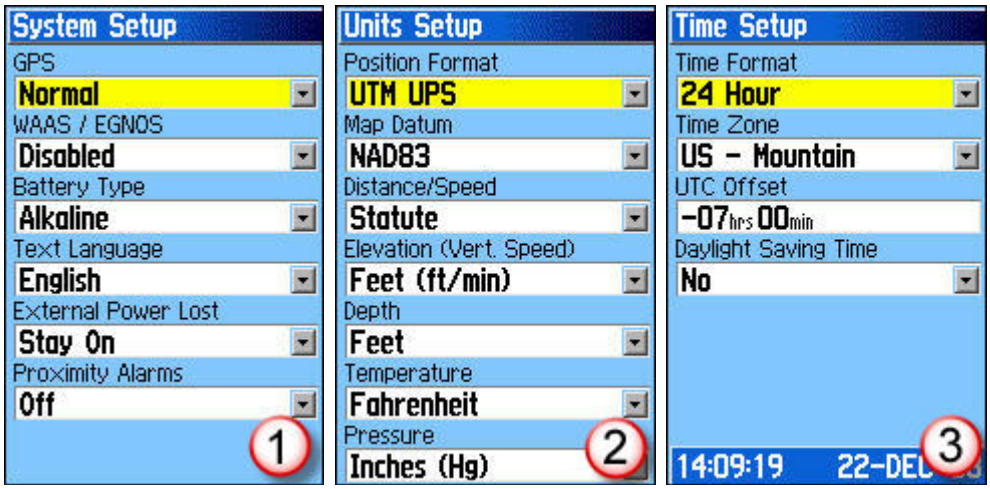
Primary access to the receiver's functionality and configuration is gained through the **Main Menu** and **Setup Menu** pages.

Press **Menu - Menu** to expose the **Main Menu** page, below left. Then select **Setup** and press **Enter** to expose the **Setup Menu**'s list of setup items, below right.

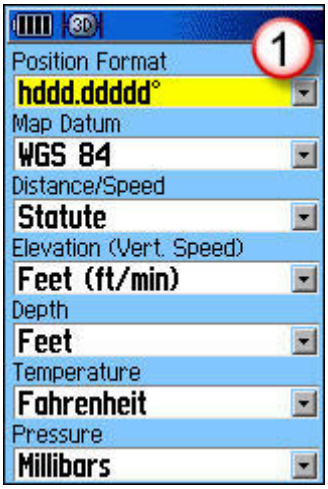
Select a setup item and press **Enter** to view or modify its parameters.

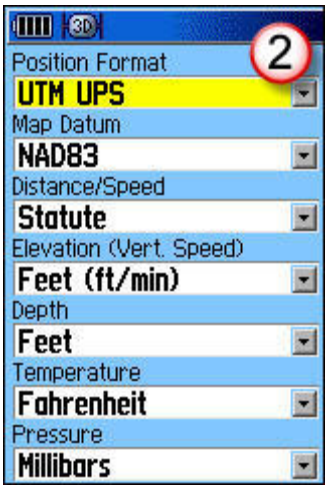
Typically, the setup items of primary interest include:

- **System**, Figure 1 - 76CSx Example
- **Units**, Figure 2 - 76CSx Example
- **Time**, Figure 3 - 76CSx Example



2.5 Position Format and Map Datum





Garmin GPS receivers capture and store positions as decimal degrees of latitude and longitude referenced to the WGS84 datum. Although users can set how GPS positions are displayed on-screen, those settings have no effect on how the GPS positions are actually captured, or stored, internally.

To configure on-screen position display, press **Menu – Menu**, select **Setup** and press **Enter**, select **Units** . Then select the **Position Format** and **Map Datum** fields in succession, and set them as desired.

For example, format **hddd.ddddd** and datum **WGS 84** (Figure 1) will capture and store GPS positions as decimal degrees of latitude and longitude referenced to the WGS84 datum, and will also display them on-screen as WGS84 decimal degrees.

Format **UTM UPS** and datum **NAD83** (Figure 2) will also capture and store GPS positions as decimal degrees of latitude and longitude referenced to the WGS84 datum, but it will display them on-screen as Universal Transverse Mercator (UTM) NAD83 coordinates.

(76CSx Examples Shown on Right)

2.6 When Position Format and Map Datum matter

A receiver's Position Format and Map Datum settings are not critical if users upload or download tracks and waypoints electronically using DNRGarmin or MxGPS, for instance. Remember, Position Format and Map Datum settings only affect on-screen coordinate display. They do not affect internal data capture and storage.

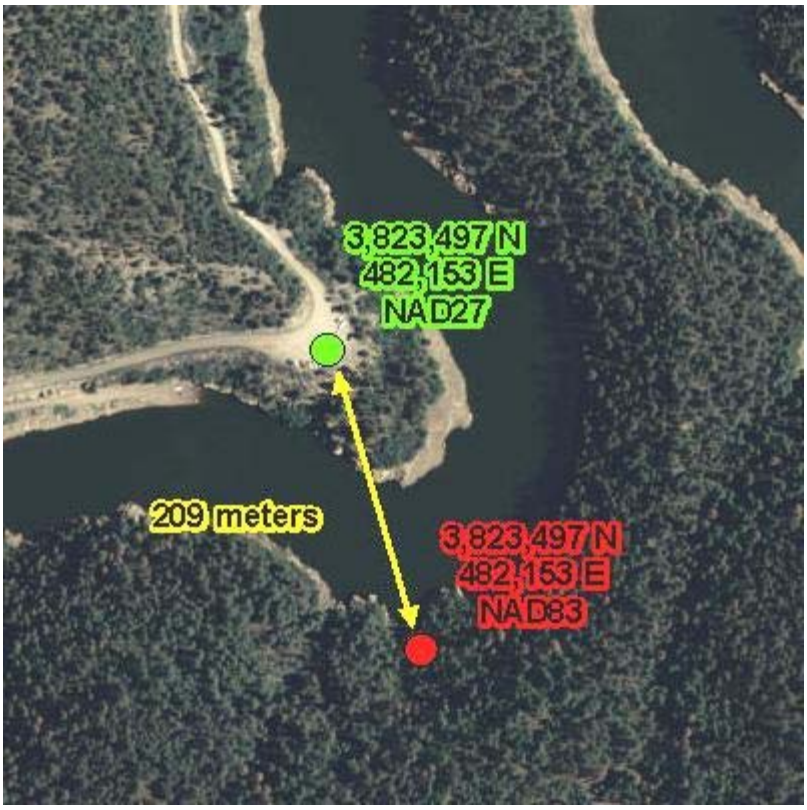
However, a receiver's Position Format and Map Datum settings are **critical** in these three situations.

A. If users **manually copy**, or **verbally report**, GPS coordinates directly from the receiver's screen, they must also record or report the receiver's current Position Format and Map Datum settings.

B. If users **manually enter waypoint coordinates** into a receiver, they must also make sure that the receiver's settings match the coordinates' Position Format and Map Datum.

C. If the receiver is **supplying NMEA-format GPS data to ArcPad**, the receiver's Position Format and Map Datum must be set to **hddd.ddddd** and **WGS 84** respectively.

Unrecognized datum shift may have consequences if the mis-applied coordinates refer to a safety zone, drop point, medevac point, helispot, or any other critical feature.



To alleviate potential datum mis-match issues, GPS users should follow these guidelines:

1. Verify which datum and coordinate system are officially sanctioned for the task, and use them.

2. When receiving coordinates provided by another, always verify which datum those coordinates are referenced to, and use that datum.

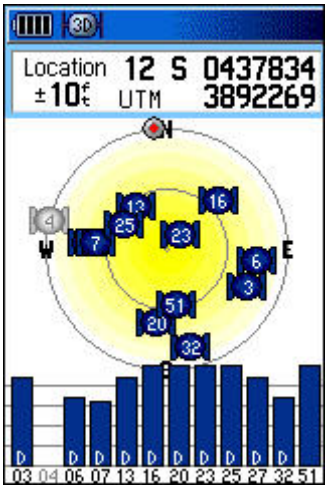
3. When plotting coordinates from a map, use the map's legend to determine which datum the map's coordinates are referenced to.

4. When passing GPS coordinates on to other users, always provide them with the datum those coordinates are referenced to.

5. When manually entering coordinates into a GPS receiver, set the receiver's map datum and pocation format to match those of the coordinates.

2.7 Using WAAS

The Wide Area Augmentation System, or WAAS, is a satellite-based real-time differential correction service. Under ideal conditions, Garmins receiving 100% WAAS corrections could achieve 1 – 3 meter accuracy.



Garmin receivers indicate receipt of the WAAS correction message for each individual satellite in a working constellation by displaying a "D" in the satellite's signal strength bar. WAAS improves accuracy of autonomous GPS positions but relies on direct line of sight to one of two geostationary satellites. Ensure GPS is held upright (use bracket in aircraft or external antenna) to maximize view of southern sky for highest accuracies.

(76CSx Example Screen Shot at Right)

2.8 Prepare for and collect an averaged waypoint – 76CSx Example

It is generally good practice to delete all waypoints from a receiver prior to a GPS session unless they are needed for ongoing work, or for future download. To delete all waypoints:

1. Press **Find**, select **Waypoints**, and press **Enter** to view the list of waypoints, Figure 1.

   Press **Menu** to select how waypoints are listed. **Find By Name** lists all waypoints in alphabetic order. **Find By Nearest** only displays waypoints "nearest" your location, and lists them in order of their distance. **Find By Name** assures that all waypoints are listed.

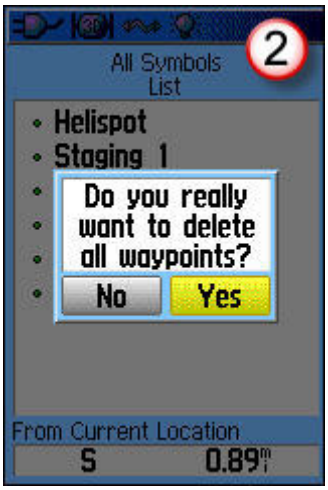
2. Press **Menu**, select **Delete…**, select **All Symbols**, press **Enter**, and confirm **Yes**, Figure 2.

To capture a new waypoint (a point feature):

3. Press (and hold, if necessary) **Mark**, select **Avg**, and press **Enter**, Figure 3.

4. Remain on station until a minimum of 30 positions have been captured (the **Measurement Count** field), select **Save**, and press **Enter**, Figure 4. These positions will be averaged to create a single waypoint.

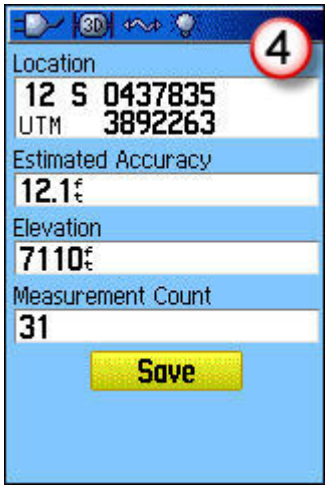
5. Accept the default waypoint name (a sequential number like **002**), or give the waypoint a new name.

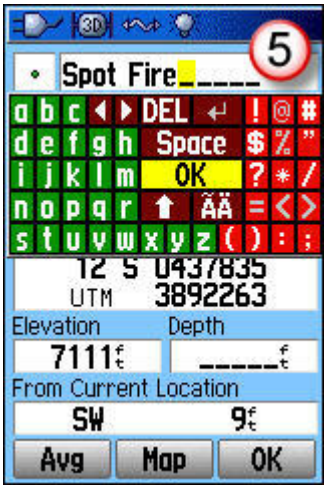


To give the waypoint a new name:

a.) Select the waypoint's **ID** field with the rocker key and press **Enter**. Then, use the alpha-numeric keypad to spell out a new name of 14 characters or less, **Spot Fire** for instance.
b.) Select **OK** and press **Enter** to dismiss the keypad, Figure 5.
c.) Select **OK** and press **Enter** to complete waypoint capture.

Most recent-model receivers can accommodate 1,000 waypoints. (76CSx Example)





2.9 Update a waypoint's location

There are situations when it is very handy to be able to update the location of an existing waypoint.

To update a waypoint's existing location to the receiver's current location:

a.) From the waypoint's page, press **Menu**, select **Average Location**, and press **Enter**.
b.) Remain on station until a minimum of 30 positions have been captured (the **Measurement Count** field), select **Save**, and press **Enter**. These positions will be averaged to create the waypoint's new, updated location.

Figure 1: Notice that the helispot was 1.04 miles away prior to updating the waypoint's **Location.**

Figure 2: After update, the **From Current Location** distance is 5 feet instead of 1.04 miles**.** Also, the **Note** field was edited to indicate that the Helispot's location was updated on 22-June-2008.
(76CSx Example)

2.10 Create a waypoint manually

Waypoints can be created "from scratch". For example, handwritten coordinates for a pump's location can be manually entered to create a new waypoint for the pump. Remember that the receiver's **Position Format** and **Map Datum** must be set to match the coordinates' Position Format and Map Datum prior to entering the coordinates.

To create a new waypoint manually: (76CSx Example)

1. Press **Mark** to create a new "dummy" waypoint.

2. Use the rocker key to move to, and edit, the waypoint's **ID** (name) field.

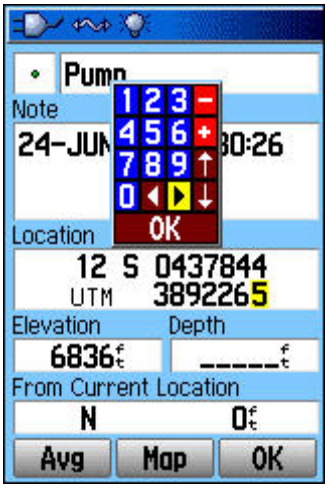
3. Use the rocker key to move to the **Location** field and press **Enter**.

4. Use the numeric keypad to manually enter coordinates, as illustrated at right.

   For UTM coordinates, the zero-padded Easting is entered on the first line, and the Northing is entered on the second line.

5. Check coordinates for accuracy. Then select and press **OK** to dismiss the numeric keypad.

6. Press **OK** to confirm the new waypoint.



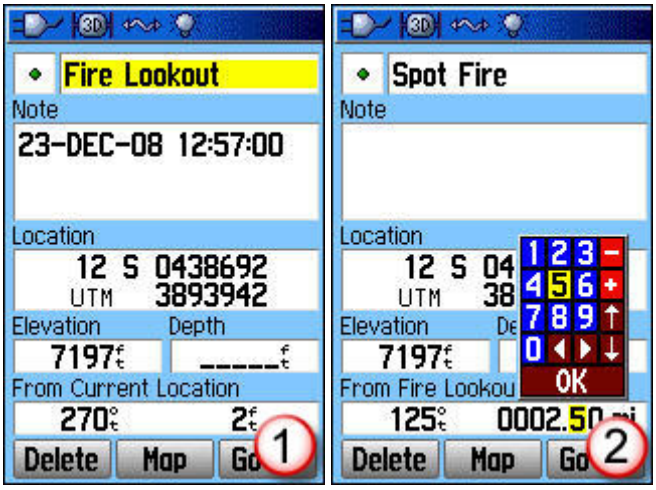
2.11 Create a waypoint by projecting an existing waypoint – 76CSx Example

A new waypoint can be created by "projecting" an existing waypoint.

1. Browse to an existing waypoint's page, like **Fire Lookout** in Figure 1.

   Press **Menu - Project Waypoint**.

2. Use the rocker key and press **Enter** to edit the projected distance (2.5 miles) and the direction (125°T) using the numeric keypad, as in Figure 2.



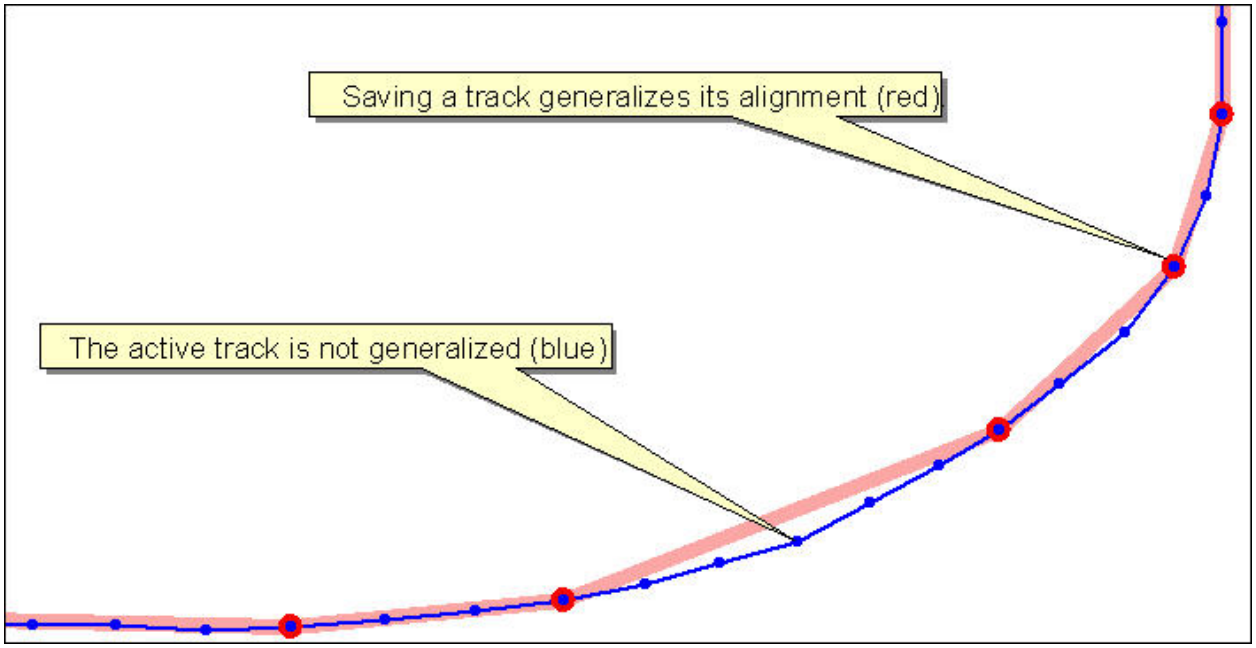
2.12 Track logs

A track log is a sequence of GPS positions that can be converted into point, line, or polygon GIS features using DNRGarmin software (for example). When the track log feature is turned on, positions are automatically captured at a regular interval into the **active track log** for as long as the receiver is powered on, or until the track log feature is turned off, or until track log memory is full.

A new track segment is created in the active track log every time the active track log is cycled **Off** and **On**, and each time the receiver is powered **Off** and **On**.

The active track log, or portions of it, may be copied to a "saved" track. Saved tracks have the characteristic of being a "generalized" version of the active track. In the illustration below, an active track log is represented by the blue points and line. The corresponding saved track is represented by the red points and line. Notice that the saved track is not as detailed as the active track log. Users wishing to preserve the maximum amount of track log detail should not create saved track logs.

Most receivers can accommodate 10,000 GPS positions in the active track log, and 20 saved tracks.



2.13 Configure the active track log – 76CSx Examaple

To access the Tracks page (Figure 1), press **Page** until the Tracks page cycles up, or press **Menu – Menu – Tracks**, and press **Enter**.

It is generally good practice to clear or delete all track logs from a receiver prior to a GPS session unless they are needed for ongoing work, or for future download.

To clear (empty out) the active track log select **Clear**, press **Enter**, and confirm **Yes** from the Tracks page. The active track log will now show 0% full, Figure 2.

To delete all saved tracks, press **Menu** from the Tracks page, select **Delete All Saved**, and confirm **Yes**. The 3 saved tracks have now been deleted, Figure 2.

Turn the active track log **On** and **Off** by using the rocker key to highlight either the **On** or **Off** position (Figure 1), and then pressing the **Enter** key to activate the selected position.

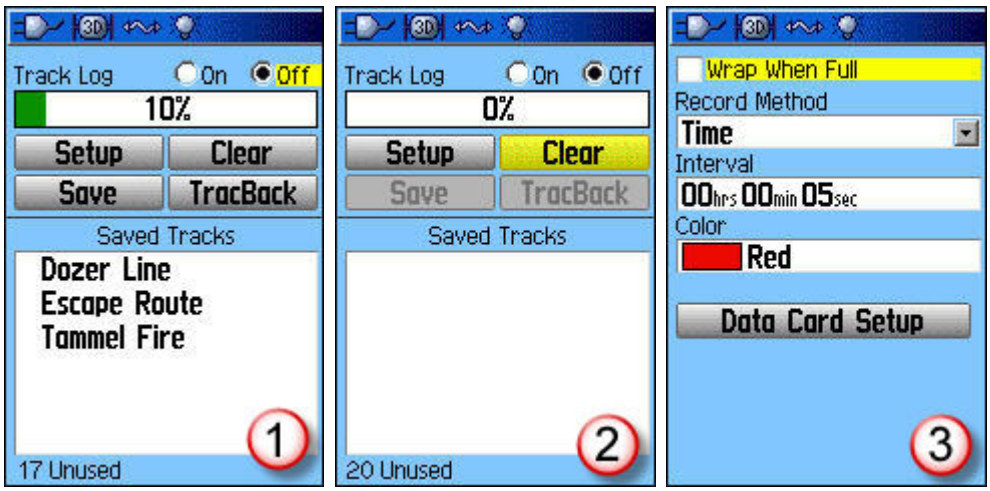
Configure the active track log by selecting **Setup** from the **Tracks** page and press **Enter**. The settings illustrated in Figure 3 are a good general recommendation.

If **Wrap When Full** is not checked, the active track will stop logging positions when its 10,000 position limit is reached. If it is checked, it will "wrap", and begin over-writing previously logged positions.

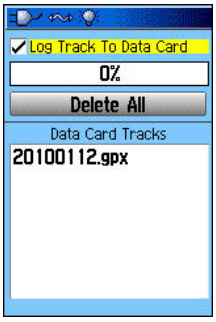
Time is the recommended **Record Method**. Other choices include **Auto** and **Distance**.

Set a recording time **Interval** that is appropriate for your anticipated travel speed. A short interval (1 sec) may be appropriate when driving, while 10 – 15 seconds may be appropriate if on foot in very difficult terrain. The **Interval** can be changed even while the active track is turned on.

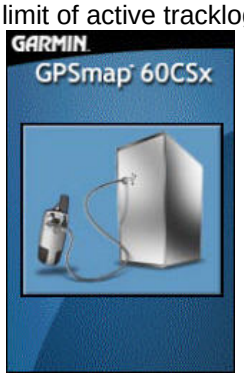
The active track's color when viewed on the receiver's Map page can be set as desired, red in this - 76CSx Example, Figure 3.



2.14 Capturing the active track log in .gpx format – 60CSx Example

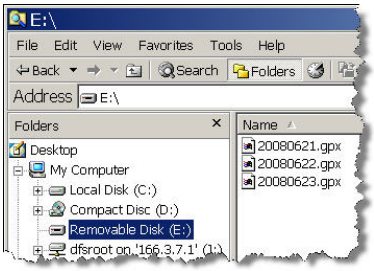


In addition to the active track log itself, receivers equipped to do so can log active track positions to a micro-SD card in a broadly generic **.gpx** format by selecting **Data Card Setup** from the **Track Log Setup** page, pressing **Enter**, and placing a check in the **Log Track To Data Card** box, as at right. Tracklog points stored in GPX format are stored in daily files (using UTC time). the first 10,000 tracklog points stored in the active tracklog also are replicated in the GPX storage. The advantage of GPX is the nearly unlimited storage capacity of GPX beyond the 10,000 trackpoint storage limit of active tracklog.



The **.gpx** files are compatible with many GPS applications, and can be retrieved from the micro-SD card by connecting the receiver to a PC with a USB cable and pressing **Menu – Menu – Setup – Interface – USB Mass Storage**.

The receiver will display a screen similar to that at left, signifying that it has temporarily gone into USB flash drive mode, and can't be used for other purposes. While in this mode, users can browse to the micro-SD card's contents using Windows Explorer, below.

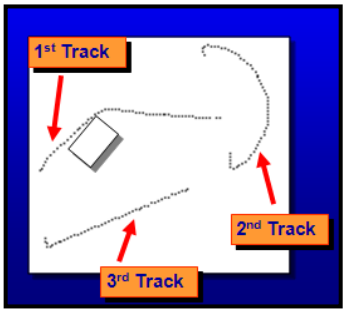


Click the PC's **Safely Remove Hardware** icon to restart the receiver, and restore its normal functionality.

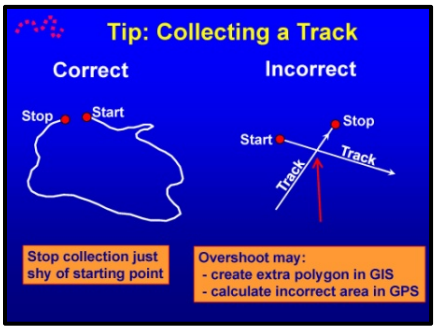
2.15 Using the active track log

To capture GPS positions into the active track log:

1. Travel to a feature's point of beginning.
2. Turn the active track log on by using the rocker key to select the **On** position, and pressing **Enter**.
3. Begin travel along the feature's alignment.
4. Turn the active track log off at the end of each feature's alignment, or when not actively following the feature's alignment. Turn the active track log off by using the rocker key to select the **Off** position, and pressing **Enter**.



It is easy to create "clean" track segment ends by turning the active track log on or off while moving. For instance, as users approach the end of a track segment, they could use the rocker key to "pre-select" the **Off** position so that all they have to do is press **Enter** to cleanly close the track segment.



When collecting a closed track (as in a fire perimeter), always stop the track log before reaching the starting point. Generally a minimum of 10 feet between start and stop points is sufficient. Trying to close a perimeter track log at the same spot where the track log was started can create errors in the data when exported to a GIS, and can also cause incorrect area calculations in the GPS receiver.

2.16 Saved tracks

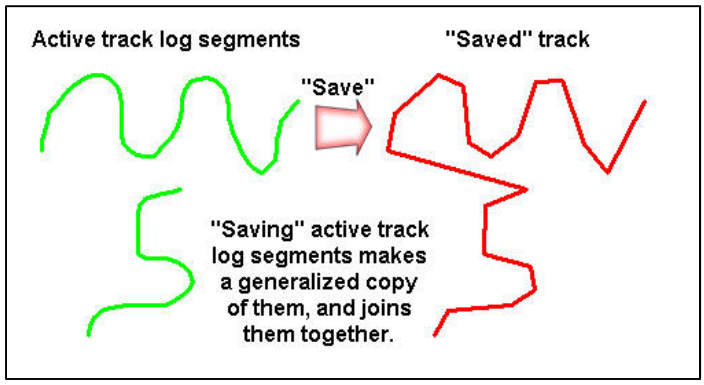
Garmin's use of the term "Save" is unfortunate, as the active track log is already secure in non-volatile memory, and can only be cleared by a user's deliberate action. Saved tracks are actually a generalized (simplified) copy of the active track log's segments

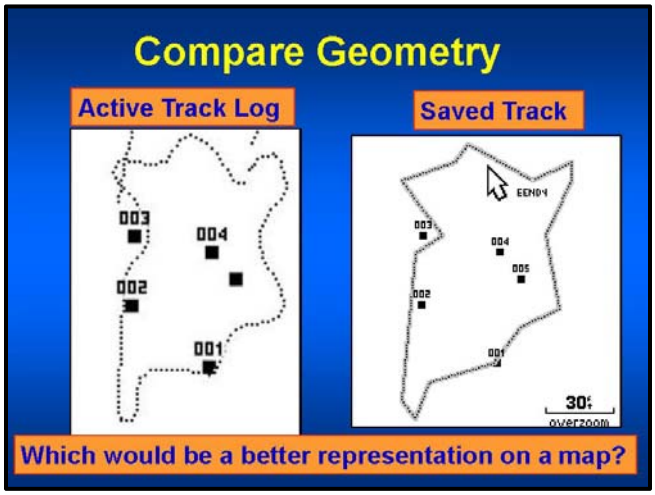
Remember that saving an active track log:

A. Creates a generalized (simplified) copy of the active track log segments;

B. Joins the active track's segments into a single saved track segment; and

C. Does not clear the active track log.





2.17 Data Collection Tips and Forms

2.17.1 - Consider how your mode of travel may affect your collection method…

- Helicopter
- Fixed Wing
- Vehicle
- ATV
- Foot
- Others?

If collecting by time, your collection interval should be determined by your speed.
Other tips:

- Slow down around corners to ensure positions are captured,
- Collect waypoints at critical junctions or corners
- Consider marking waypoints all along track as a back up
- Use external antennas when needed – especially in a vehicle.

2.17.2 - In a helicopter or fixed wing is not the place to learn your GPS. You must be able to move through menus efficiently, especially if you are prone to air/motion sickness.
Tips:

- Nomex gloves make button pushing easier
- It's hard to see the fire from the back seat (especially if the doors are closed), so you must rely on field observer skills.
- Talk to the pilot – he or she can help you see the fire or whatever feature you are mapping. Ask to go low and slow; ~ 25 knots.
- Your paper map may be needed as a backup or for orientation
- Bring an extra GPS in case your batteries die or just as a backup – put one in your shirt pocket
- Secure cables or external antennas. Use your wrist strap on the GPS
- Take air sickness precautions. GPS flights are not the same as other drop point flights – they are curvy, smoky, etc.

2.17.3 - Always check your mission checklist before going out.

Were you briefed and do you understand?
Do you have the proper equipment?
Is the GPS prepared?

Incident GPS Pre–Mission Checklist

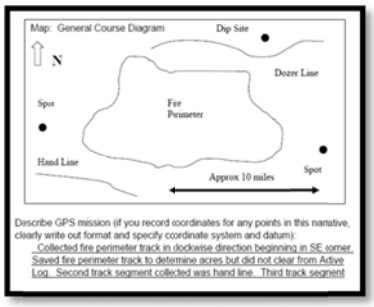
Briefing	Briefing
Mission Objective(s) Understood/Clear	
Logistics to Execute/Complete Mission Clear	
Data/Product Datum Format Clear	
Delivered Data/Product Format Clear	

2.17.4 - Metadata is data about the data. The metadata field form should be filled out for every GPS mission. Always include a metadata field form when giving GPS data to a GIS specialist.

Incident GPS Metadata Form (Field Log)

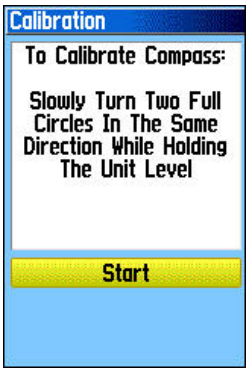
Metadata completed by: Kerri Mich Date: 3/17/2008
Date of data collection (mm/dd/yyyy): 3/17/2008
Time of data collection: Start: 1500 Stop: 1630
Data collector(s) name: Kathie Hansen
Collector's contact information: 920-866-1767, kathie_hansen@nps.gov
Location of GPS work (Park/Forest/Preserve/County): Wind Cave NP
State/Province: SD
Purpose of GPS survey: fire perimeter recon
Incident name: Bear Creek Fire Unit ID: SD-WCP
GPS equipment: Make : Garmin Model GPSMAP76S

Sketch a map of your data collection and write a narrative of the mission. This will help if there are questions about your data.



2.18 Prepare for navigation

2.18.1 - A receiver's Compass page includes a compass needle that facilitates navigation. If the receiver does not have an electronic compass, or if the electronic compass has been turned off, the compass needle relies exclusively on changes in GPS position to determine its pointing direction. Therefore, users must keep moving if an active compass needle is desired. If users stop moving, the compass needle will begin to drift, and become unreliable.



Garmin receivers having an "S" in their name, like GPSMap76CSx, are equipped with a live electronic compass. Calibrating a compass compensates for natural or man-made variations surrounding the compass that can pull the magnetic needle from pointing to the earth's magnetic north. Calibrate a compass whenever you receive a compass from someone else, or enter an aircraft, a car or the environment you are mapping dramatically changes. .

The compass needle will always remain "live" (in an active state) when the receiver's electronic compass has been turned on and calibrated. However, use of the electronic compass will reduce battery life somewhat, so be sure to turn the electronic compass off by pressing and holding the **Page** key when it is no longer needed.

2.18.2 – Navigation functions operate in either **Course** mode or **Bearing** mode regardless of whether or not the electronic compass is activated.

- In **Bearing** mode, the receiver issues navigation instructions designed to reach the navigation target directly from the current location. Most users prefer this mode, and it is recommended.
- In **Course** mode, the receiver issues navigation instructions designed to keep the user on the navigation session's original course. Many users find this mode awkward and difficult to interpret, and it is not recommended for general use.

  The compass is in **Course** mode if it has as a dotted course line across its face, right. If desired, press **Menu**, select **Bearing Pointer**, and press **Enter** to put the compass into **Bearing** mode.

2.18.3 – Users can customize the number and content of data fields that appear on the Compass page.

2.19 Begin navigation

Users can navigate to their receiver's waypoints.

To select, and begin navigation to, a waypoint- 76CSx Example:

1. Press **Find**, select **Waypoints**, and press **Enter**.

   Select the waypoint ID representing the desired destination, Figure 1, and press **Enter**.

2. Select **Go To** from the waypoint's page to activate the navigation session, Figure 2.

2.20 Navigate Using Compass Page

1. Press **Page** until the Compass page appears, right.

2. The Compass page features a "compass ring" and up to four user-selectable data fields described in section 2.18.3.

3. Follow the Compass page's red arrow to the destination. Remember to use the **Bearing** option, not the **Course** option.

4. The Compass page illustrated at right indicates that:

   a. The destination is **Safety Zone**.

   b. Distance to the destination is **0.33 miles**.

   c. Estimated time to destination is **2 minutes, 3 seconds**. Time to destination may not be accurate if speed and/or direction are changing rapidly.

   d. Current direction of travel is about **215°**.

   e. Bearing to the destination is about **175°**.

2.21 Arrive at navigation target

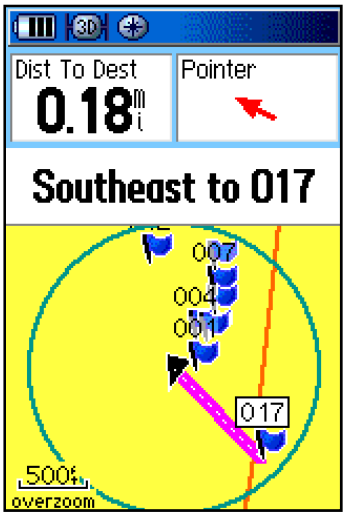
A beep and an on-screen arrival message will appear as the destination is approached, right. You'll know you're getting close when the compass pointer begins to "dance" and you begin to do the "getting-to-zero" shuffle.

Use your knowledge of the accuracy to know when you are within the error of your position. When you get less than 5-10 meters away, the navigation aid is no longer helping you, look ahead and pick out your target or a reasonable stopping point.

To clear the navigation session and "release" the navigation target, press **Menu** from the Compass page, select **Stop Navigation**, and press **Enter**.

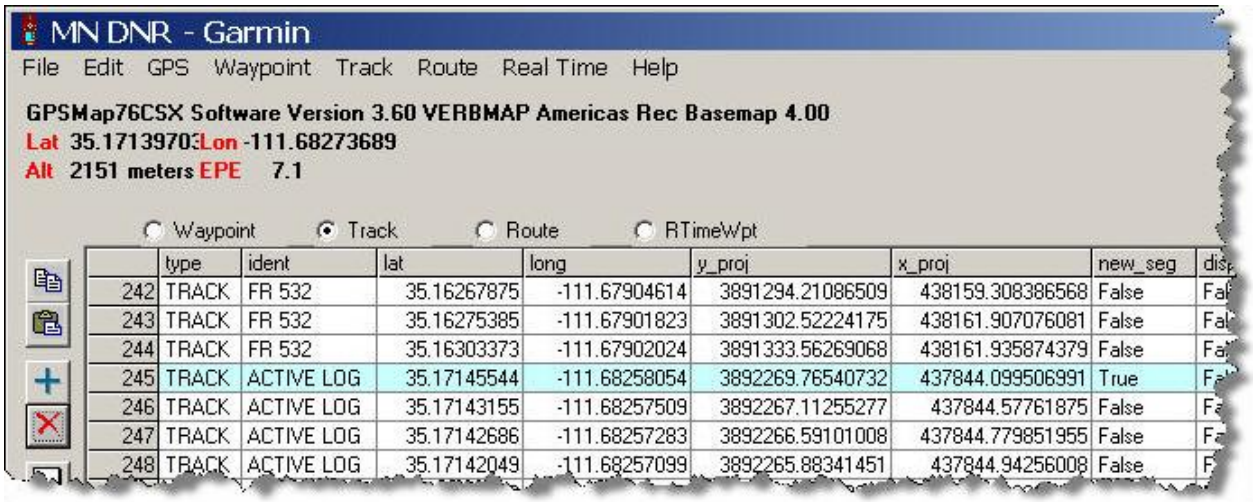
2.22 Navigate Using Map Page

Another page that can be used for navigation is the map page. Keep in mind that the map page can be edited to display different data fields that may be helpful for navigation. To edit the map page, press the **Menu** key while viewing it.



Chapter 3 - Using DNRGarmin Software

3.1 Background



DNRGarmin is free software that facilitates exchange of data between Garmin GPS receivers and several common GIS file formats.

Data can be exported directly to, or imported directly from, ESRI shapefiles (.shp), existing ESRI geodatabase (.mdb or .gdb) feature classes, text files (.txt), dBase files (.dbf), Google Earth MyPlaces files (.kml), and GPX files (.gpx).

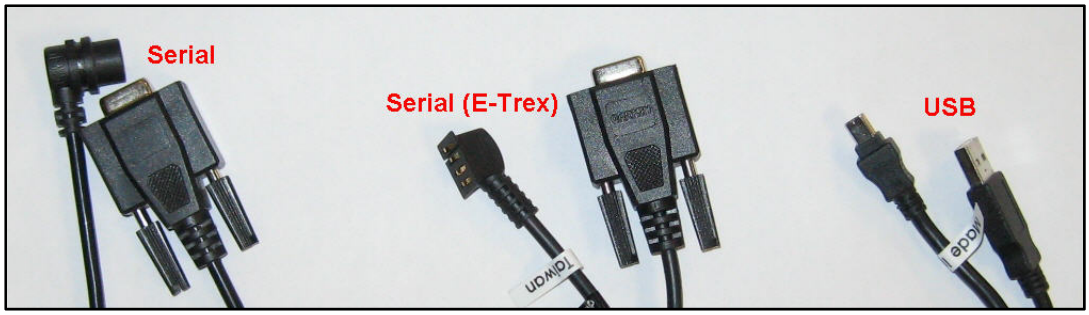
DNRGarmin can be run as a stand-alone application, but its functionality is enhanced when run in combination with ArcMap.

Download the current version of DNRGarmin from:
http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmin/DNRGarmin.html

A Garmin GPS receiver can be connected to a PC using either a proprietary Garmin serial cable, or a standard USB cable. Several Garmin-compatible cables are illustrated below.

A Garmin USB driver is required to facilitate a USB connection, but a serial connection doesn't require a driver. Download the current Garmin USB driver from:
http://www8.garmin.com/support/download_details.jsp?id=591

Users lacking a 9-pin serial port on their PC must purchase a serial-to-USB adapter if they are to accommodate older Garmin receivers that communicate only via serial interface.



3.2 Open and configure DNRGarmin

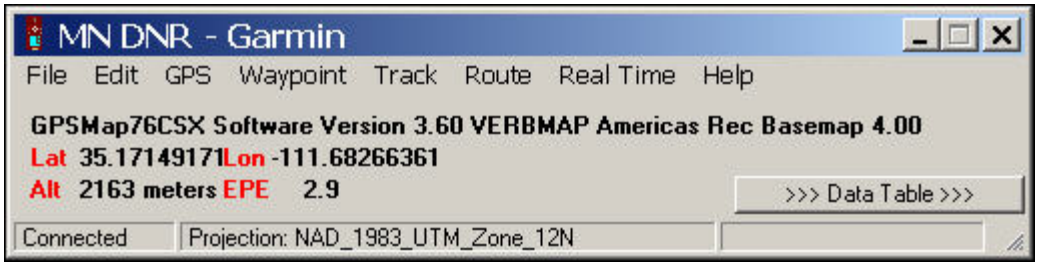
Follow these steps to open DNRGarmin.

1. Open ArcMap and activate the DNRGarmin toolbar by clicking **View – Toolbars – DNR Garmin Toolbar**, right.

2. Connect a Garmin GPS receiver to the PC using a serial or USB cable, and turn the receiver on.

3. Click **Open DNRGarmin** on ArcMap's DNRGarmin toolbar.

4. To open DNRGarmin as a stand-alone application, click **Start – All Programs – DNRGarmin – DNRGarmin**, or double-click the DNRGarmin desktop icon, right.



If DNRGarmin's status bar doesn't indicate **Connected** after a few moments, check connection settings by clicking **GPS – Set Port** and **GPS – Set Baud Rate**. Typical port choices are **USB** or **Port 1** (a serial COM port). Garmin's baud rate is **9600**.

If a connection still can't be established, check that the receiver's protocol is set to **Garmin**, and not to **NMEA**, by browsing to **Main Menu – Setup – Interface** on the receiver.

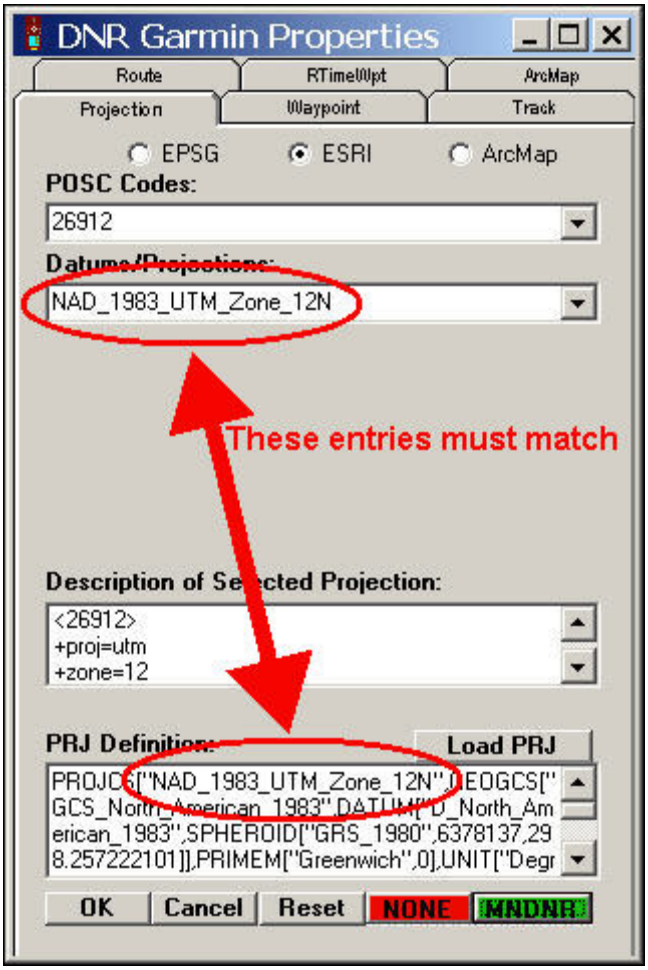
Make sure the status bar's **Projection:** matches the projection of the intended source or target GIS layer. For instance, DNRGarmin's projection must be set to NAD_1983_UTM_Zone_12N if its GPS data will be exported to a shapefile having a NAD_1983_UTM_Zone_12N spatial reference. Mis-matched projections will produce mis-aligned features.

Consult a local GIS or GPS specialist if unsure which projection is appropriate.

If the appropriate projection is not indicated, click **File – Set Projection** in DNRGarmin.

Click the **ESRI** option, and select the desired projection from the **Datums/Projections:** dropdown list, right.

Specifying the correct datum and projection is critical for proper data projection and transformation! Make sure it is set correctly.



DNRGarmin can also attach an explicit spatial reference to exported features. To facilitate this functionality, click the **Load PRJ** button, browse to, and select the projection file corresponding to the currently selected projection. When set correctly, entries in the **Datums/Projections:** box and the **PRJ Definition:** box should match.

This **Load PRJ** step is also critical for data integrity! Just like a purebred dog without AKC papers, the lineage of projected spatial data without an explicit spatial reference is suspect.

This process only has to be performed once for each selected projection, as it creates a permanent registry association between the selected projection and the corresponding projection file parameters.

Click **OK** when entries are complete.

3.3 Download GPS track logs

To download a receiver's active track log, and all saved tracks, click **Track – Download**. The download process does not delete active and saved tracks from the receiver.

Each track log vertex is transferred to DNRGarmin's table, as illustrated above. All track log vertices, or only those of interest, can be selected for export. Unfortunately, non-contiguous selections are not supported.

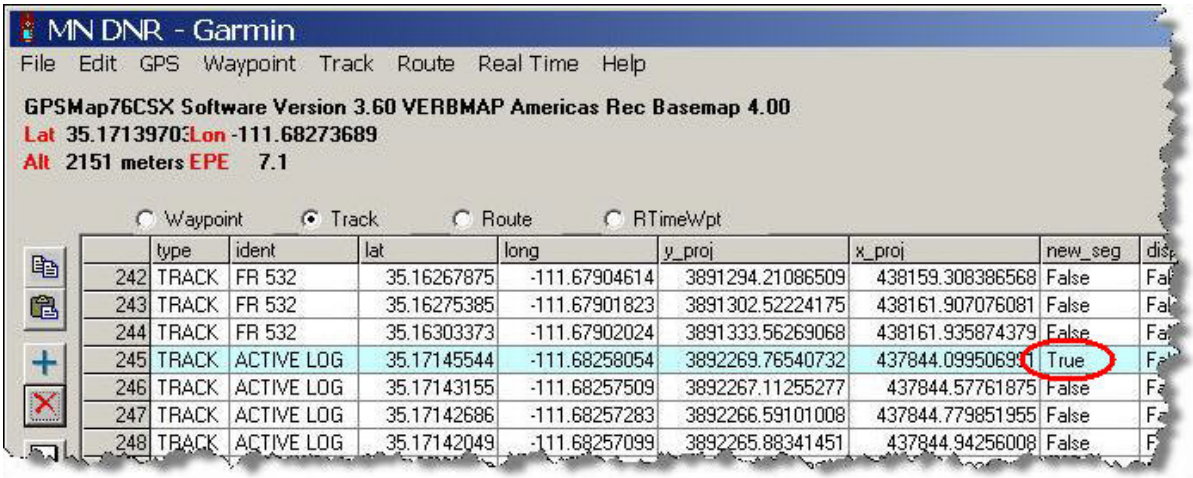
All vertices collected since the active track log was last cleared are included in the **ACTIVE LOG** track.

Vertices from saved tracks, like **FR 532**, include only the generalized version of active track log vertices. These should NOT be saved to shapefile. It's easiest to delete saved tracks from this table by selecting them and clicking the **Delete** button.

Each record includes the track's name (**ident**), its WGS84 latitude (**lat**) and longitude (**long**) expressed as decimal degrees, and its coordinates referenced to DNRGarmin's currently selected projection (**y_proj** and **x_proj**). Field visibility can be controlled by clicking **Track – Track Properties…**.

The first record of each track segment is highlighted with a light blue color, and has the value "**True**" in its **new_seg** field. A new segment is created in the active track log each time the GPS receiver is turned off and on, or each time the active track log is cycled off and on. Each segment will appear as a separate line or polygon when converted to GIS features.

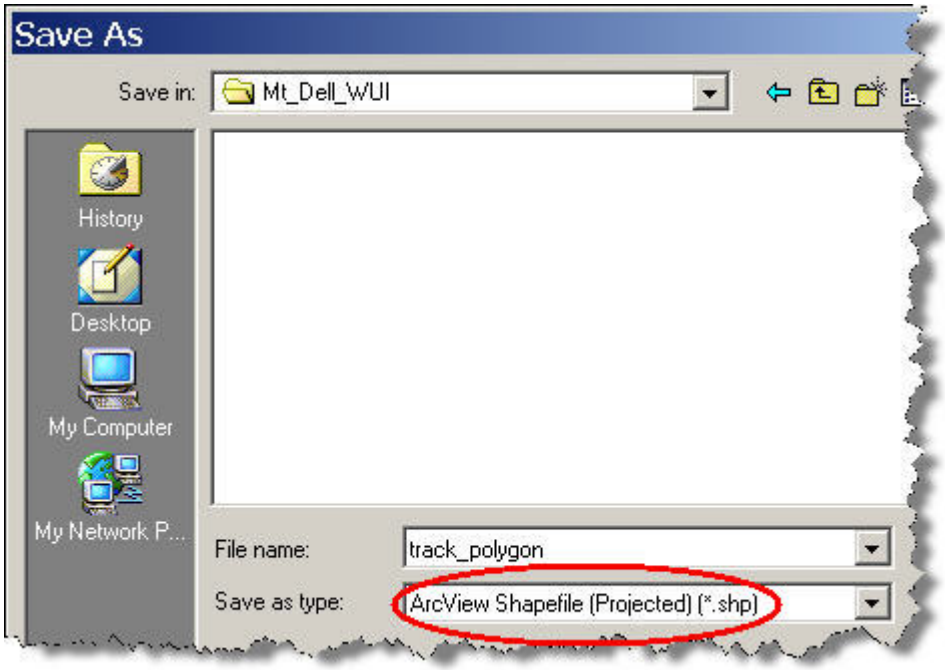
Adjoining segments can be combined into a single segment in DNRGarmin by double-clicking the "**True**" cell that separates the adjoining segments, and changing its value to "**False**".



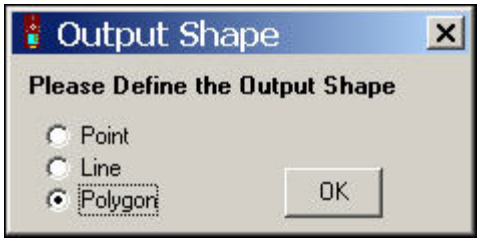
	type	ident	lat	long	y_proj	x_proj	new_seg	dis
242	TRACK	FR 532	35.16267875	-111.67904614	3891294.21086509	438159.308386568	False	Fal
243	TRACK	FR 532	35.16275385	-111.67901823	3891302.52224175	438161.907076081	False	Fal
244	TRACK	FR 532	35.16303373	-111.67902024	3891333.56269068	438161.935874379	False	Fa
245	TRACK	ACTIVE LOG	35.17145544	-111.68258054	3892269.76540732	437844.09950699	True	Fa
246	TRACK	ACTIVE LOG	35.17143155	-111.68257509	3892267.11255277	437844.57761875	False	Fa
247	TRACK	ACTIVE LOG	35.17142686	-111.68257283	3892266.59101008	437844.779851955	False	Fa
248	TRACK	ACTIVE LOG	35.17142049	-111.68257099	3892265.88341451	437844.94256008	False	F

3.4 Export (save) track logs to GIS

3.4.1 Shapefiles - To convert track log segments to a shapefile, select the track points that make up the feature and click **File – Save To – ArcMap – Shapefile Layer…**. Then, browse to an appropriate directory, and provide a name for the new shapefile, as shown at right.



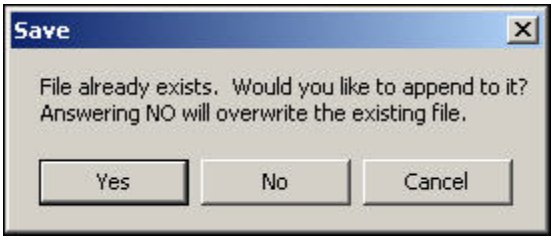
Make sure the saved file type is a **Projected** shapefile, and that DNRGarmin's projection matches the target GIS layer.



Users must indicate whether tracks are to be converted into point, line, or polygon features, left. If you feel you collected your data very well, save polygon (area) features directly to polygon and line features to lines. If you feel there may be editing needed, save polygon features and line features to points. They can be converted in ArcMap (with an extension like NPS AlaskaPak) to their respective polygons and lines.

Switch to ArcMap's data view, and inspect the new shapefile to ensure that its features are located and shaped correctly. If there are issues with your lines and/or polygons, save them again to points for easier editing in GIS. Selecting and saving should be repeated for all track segments (that make up individual line and/or polygon features).

Note: DNRGarmin can also overwrite, or append new features to, an existing shapefile that has a matching feature type and a matching spatial reference. To do so, browse to an existing shapefile name instead of providing a new shapefile name. Click **Yes** to append features to an existing shapefile, or **No** to overwrite the shapefile, right.

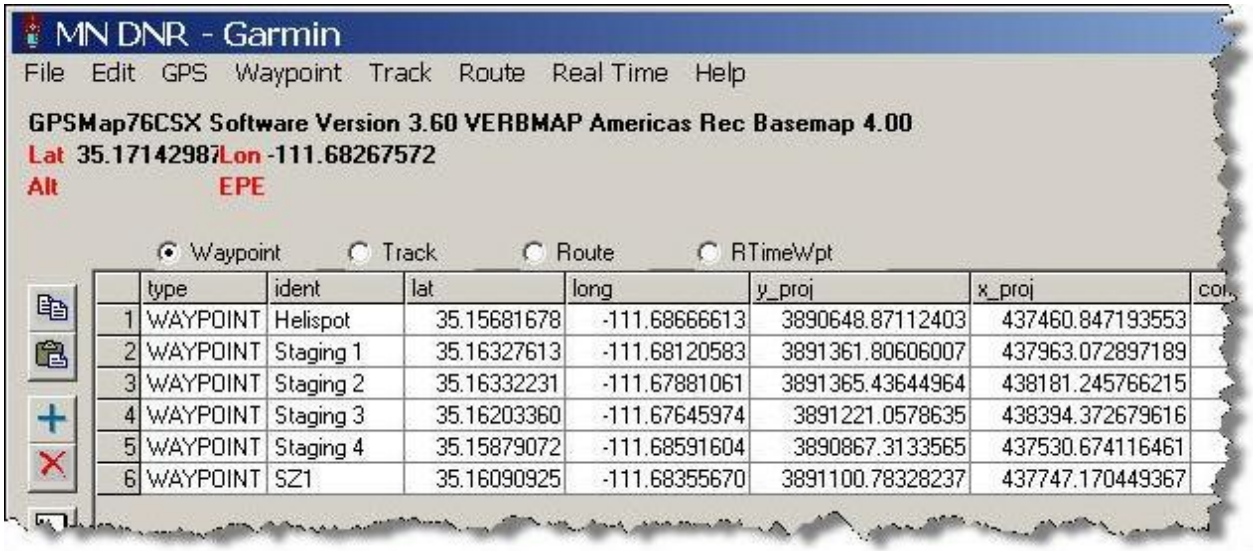


3.4.2 Geodatabase feature classes - DNRGarmin cannot create a new geodatabase feature class the way it can create a new shapefile, and it cannot append features to a feature class that isn't open in ArcMap.

To append track log segments to an ***existing*** geodatabase point, line, or polygon feature class, click **File – Save To – ArcMap – Geodatabase Feature Class…**, and browse to an existing feature class that is open in ArcMap.

As with shapefiles, feature classes can accept point, line, or polygon features from track log segments.

3.5 Download GPS waypoints



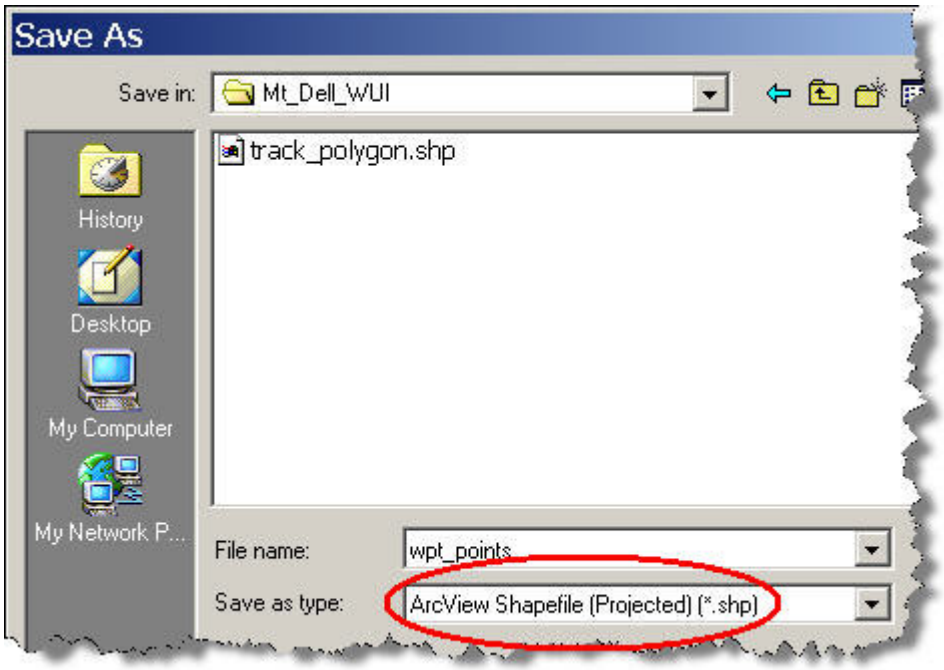
	type	ident	lat	long	y_proj	x_proj
1	WAYPOINT	Helispot	35.15681678	-111.68666613	3890648.87112403	437460.847193553
2	WAYPOINT	Staging 1	35.16327613	-111.68120583	3891361.80606007	437963.072897189
3	WAYPOINT	Staging 2	35.16332231	-111.67881061	3891365.43644964	438181.245766215
4	WAYPOINT	Staging 3	35.16203360	-111.67645974	3891221.0578635	438394.372679616
5	WAYPOINT	Staging 4	35.15879072	-111.68591604	3890867.3133565	437530.674116461
6	WAYPOINT	SZ1	35.16090925	-111.68355670	3891100.78328237	437747.170449367

To download a receiver's waypoints, click **Waypoint – Download**. Each waypoint position is transferred to DNRGarmin's table, as illustrated above. The download process does not delete waypoints from the receiver.

Each record includes the waypoint's name (**ident**), its WGS84 latitude (**lat**) and longitude (**long**) expressed as decimal degrees, and its coordinates referenced to DNRGarmin's currently selected projection (**y_proj** and **x_proj**). Click **Waypoint – Waypoint Properties…** to control field visibility.

Users may select specific waypoint records for export, or make no selection if all waypoint records are to be exported. Unfortunately, non-contiguous selections are not supported.

3.6 Export (save) waypoints to GIS



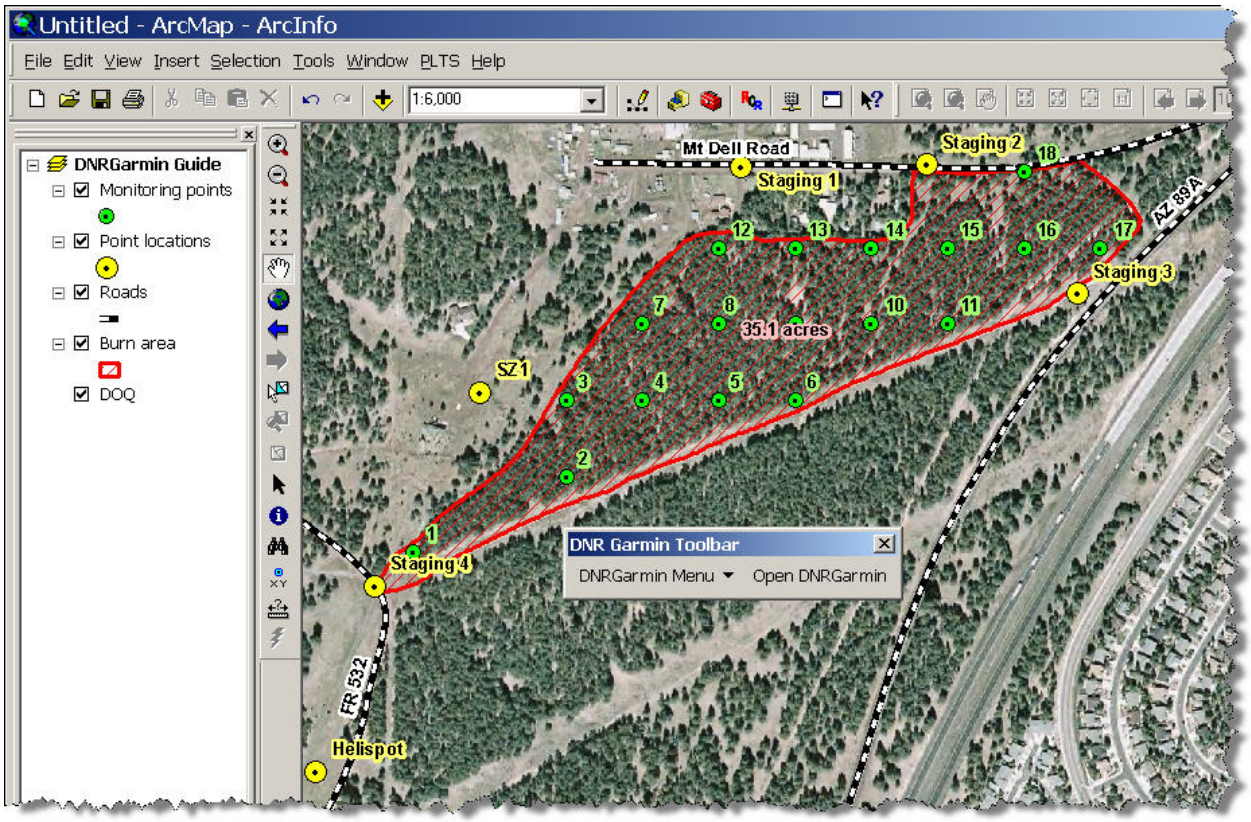
3.6.1 Shapefiles - To convert waypoint positions to a point shapefile, click **File – Save To – ArcMap – Shapefile Layer…**. Then, browse to an appropriate directory, and provide a name for the new shapefile.

Make sure the saved file type is a **Projected** shapefile, and that DNRGarmin's projection matches the target GIS layer.

Switch to ArcMap's data view, and inspect the new shapefile to ensure that its features are located correctly.

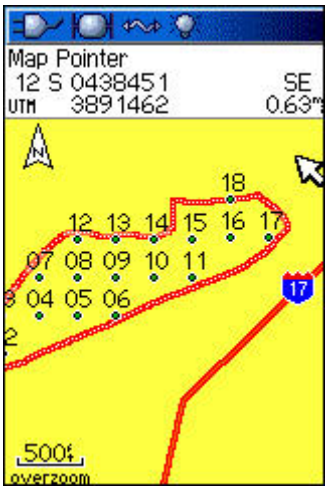
3.6.2 Geodatabase feature classes - To append waypoints to an existing geodatabase point feature class, click **File – Save To – ArcMap – Geodatabase Feature Class…**, and browse to an existing point feature class that is open in ArcMap.

3.6.3 View GPS features in ArcMap - The illustration below is an example of GIS features created using a Garmin GPS receiver and DNRGarmin software.



3.7 Create a track log from GIS features

DNRGarmin also permits users to transfer existing GIS features to a Garmin GPS receiver as waypoints, or as the active track log. In the example at right, monitoring points appear as waypoints that can be navigated to using the receiver's GPS functionality. The prescribed burn area boundary is handy for visual context, and appears as the active track log. Follow these steps to create a track log from GIS features.

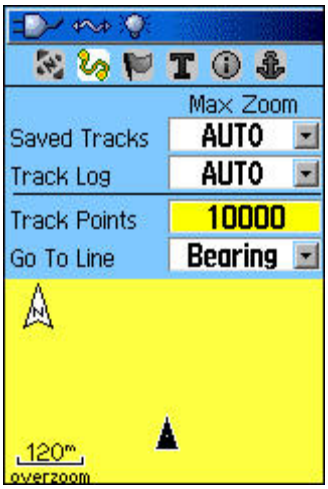


1. Turn the receiver's active track log off, and clear it.

2. Make a line or polygon shapefile or feature class active in ArcMap, ensure that DNRGarmin's current projection matches the source GIS layer, and click **File – Load From – ArcMap – Layer** to load the line's or polygon's vertices to DNRGarmin's table.

3. Then click **Track – Upload** to transfer the GIS feature's alignment to the receiver as the active track log. Keep the active track log turned off to avoid collecting new track log segments that may clutter the map view.

A typical receiver's active track log memory is limited to 10,000 vertices, so pre-select only the line or polygon features desired for the active track using **Select By Attributes…** or **Select By Location…** in ArcMap.



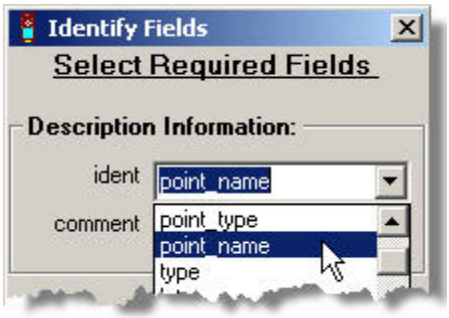
Ensure that all 10,000 track points can be rendered on the receiver's map page by pressing **Menu – Setup Map** from the map page, and changing the default **Track Points** setting from 3,000 to 10,000, as at right.

3.8 Create waypoints from GIS features

Follow these steps to create waypoints from GIS features.

1. Delete all unneeded waypoints from the receiver.

2. Make a point shapefile or feature class active in ArcMap, ensure that DNRGarmin's current projection matches the source GIS layer, and click **File – Load From – ArcMap – Layer** to load point features to DNRGarmin's table. The contents of a user-selected field (like **point_name**, at right) will become the waypoint's ID (**ident**) label.



3. Double-click the **Symbol** field's header and select a symbol for the waypoints. The City (Medium) symbol is a good choice.

4. Then click **Waypoint – Upload** to transfer the point features to the receiver as new waypoints. New waypoints will overwrite existing waypoints if they have the same ID. These waypoints can be navigated to just like waypoints created from GPS positions in the field.

A typical receiver's waypoint memory is limited to 1,000 entries, so pre-select only the point features desired as waypoints using **Select By Attributes…** or **Select By Location…** in ArcMap.

3.9 Using DNRGarmin as a stand-alone application

Even though ArcMap augments its functionality, DNRGarmin can be run as a stand-alone application.

Stand-alone procedures are identical to those described in previous sections, with these exceptions:

1. Create or append shapefiles from track logs or waypoints by clicking **File – Save To – File…**.

2. It is not possible to append geodatabase feature classes using DNRGarmin as a stand-alone application.

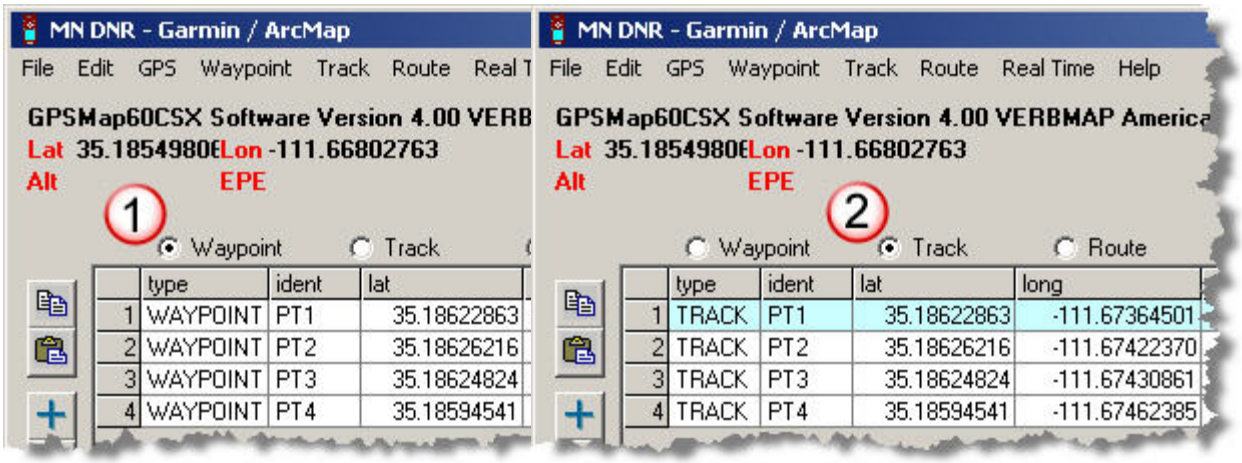
3. Create track logs or waypoints from shapefiles by clicking **File – Load From – File…**.

3.10 Other supported file formats

In addition to the shapefiles and geodatabase feature classes discussed here, DNRGarmin can export directly to, and import directly from text files (.txt), dBase files (.dbf), Google Earth MyPlaces files (.kml), and GPX files (.gpx). It is ***highly recommended*** that no matter what you save GPS data to, you also save to text file (.txt) as a back-up.

3.11 Create line or polygon GIS features from waypoints

DNRGarmin facilitates creation of line or polygon features from an ordered series of waypoints. This could be useful for features whose long, straight edges might be difficult or time consuming to traverse on foot while remaining faithful to the feature's true alignment. The procedure is described below.



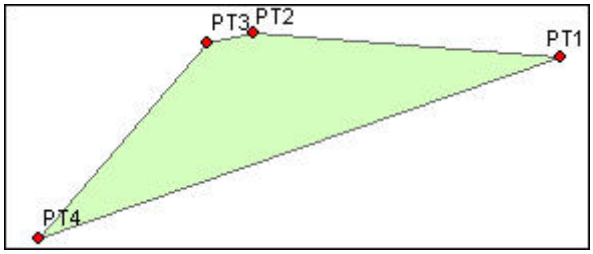
You have collected a series of waypoints representing each of the feature's corners, and name them so they can be easily sorted into the correct sequential order, like Pt1, Pt2, Pt3, and so on.

Open DNRGarmin and download the waypoints as normal by clicking **Waypoint – Download**.

1. If necessary, click the **ident** field header to sort waypoints into the correct sequential order. The result should look like Figure 1 above.

2. Click the **Track** radio button, as in Figure 2 above, to convert the waypoints into track points.

   Export the track points to line or polygon GIS features, as described in section 3.4.



The polygon at right was created from four waypoints.

Advanced Applications:

3.12 Create line or polygon GIS features by combining a track log and waypoints

DNRGarmin also permits a track log and waypoints to be combined to create either line or polygon GIS features. This could be useful if a feature's alignment or perimeter was a combination of long, straight edges and meandering curves. The procedure is described below.

1. Collect a series of waypoints representing corners of the feature's long, straight edges, and name them so they can be easily sorted into the correct sequential order, like Pt1, Pt2, Pt3, and so on.

2. Collect a track log segment representing the meandering portion of the feature's alignment or perimeter.

3. Open DNRGarmin and download the waypoints as normal by clicking **Waypoint – Download**.

4. If necessary, click the **ident** field header to sort waypoints into the correct sequential order. The result should look like Figure 1 above.

5. Click the **Track** radio button, as in Figure 2 above, to convert the waypoints into track points.

6. Select the ordered track points using the **Click and Shift – Click** method, and **Copy** them to DNRGarmin's clipboard .

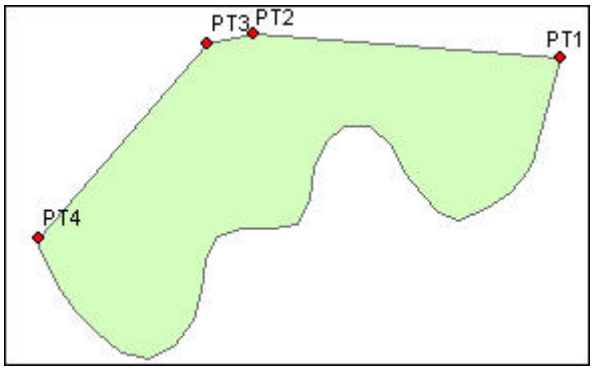
7. Download the meandering track log segment by clicking **Track – Download**.

8. Add empty track records to the end of DNRGarmin's table by clicking the **Add Record** button once for each of the converted waypoints.

9. Click in the far left cell of the first empty record, and click **Paste** .

10. Change the first added record's **new_seg** value from **True** to **False**.

11. Export the track points to line or polygon GIS features, as described in section 3.4.



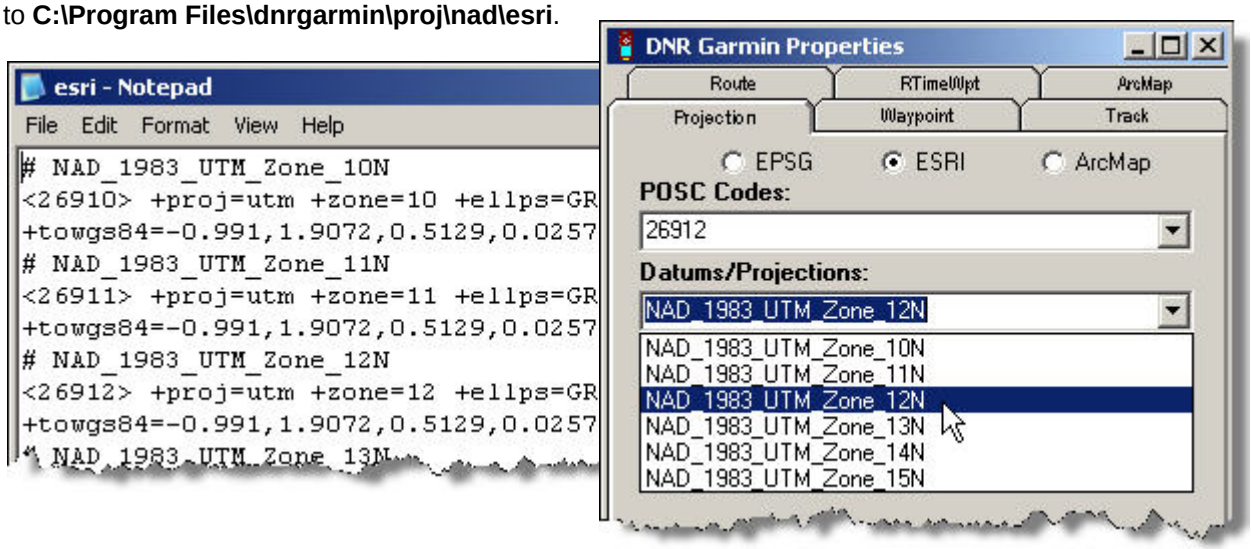
The polygon at right was created from a combination of four waypoints and a meandering track segment.

3.13 Shorten the list of Datums/Projections: choices

Users can reduce the very long list of choices in the **Datums/Projections:** dropdown list to those most frequently used. To do so, copy the file **C:\Program Files\dnrgarmin\proj\nad\esri** to **C:\Program Files\dnrgarmin\proj\nad\esri_original**. Open **C:\Program Files\dnrgarmin\proj\nad\esri** in a text editor, delete all entries except those to be retained, and save with no .txt file extension, as illustrated below left.

The resulting **Datums/Projections:** dropdown list will now be much shorter, 6 choices in this example for the western contiguous United States, and easier to browse, as below right.

If more choices are needed in the future, copy **C:\Program Files\dnrgarmin\proj\nad\esri_original** back to **C:\Program Files\dnrgarmin\proj\nad\esri**.



Chapter 4 - Exercises

4.1 Basic Garmin configuration

Press **Menu – Menu - Setup** to access the receiver's Setup Menu.

Explore and configure the **System**, **Units**, and **Time** setup pages as desired and appropriate for the local time zone.

Customize the receiver's page sequence to your liking. The **Satellite**, **Map**, **Compass**, and **Tracks** pages are recommended.

a. Press **Menu – Menu – Setup - Page Seq** to view the Page Sequence Setup, as illustrated at right.
b. To remove a page from the sequence, use the rocker key to select a page, press **Enter**, select **Remove**, and press **Enter**.
c. To add a page to the sequence, use the rocker key to select **<Add Page>**, press **Enter**, select a desired page from the page list, and press **Enter**.
d. To reposition a page within the sequence, use the rocker key to select the page, press **Enter**, select **Move**, press **Enter**, use the rocker key to move the page up or down within the sequence, and press **Enter**.

4.2 The Waypoint page

1. Create a "dummy" waypoint.
   a. Press and hold **Enter** (76C series receiver, for example), or press **Mark** (60C series receiver, for example).
   b. A typical example of a Waypoint page is illustrated at right.
   c. Use the rocker key to move among the waypoint's data fields and, if desired, press **Enter** to edit field contents.
   d. Press **Menu** to view available waypoint options, and then press **Quit** to return to the Waypoint page.
   e. Is waypoint averaging supported by your GPS receiver?
   f. Select **OK**, and press **Enter** to save the dummy waypoint.

2. Confirm the existence of datum shift.
   a. Set the receiver's **Position Format** to **UTM UPS**, and set **Map Datum** to **NAD83**.
   b. Return to the dummy waypoint's page by pressing **Find**, selecting **Waypoints**, and pressing **Enter**. Then, select the dummy waypoint, and press **Enter**.
   c. Write down the dummy waypoint's NAD83 UTM coordinates.
   d. Now, re-set **Map Datum** to **NAD27 CONUS**.
   e. Return to the dummy waypoint's page again, and write down its NAD27 UTM coordinates.
   f. Enter the coordinates into the Calculate_Datum_Shift.xls spreadsheet. It's in the Reference folder on CD

3. Delete the dummy waypoint.
   a. Press **Find**, select **Waypoints**, and press **Enter**.
   b. Select the dummy waypoint, and press **Enter**.
   c. Select **Delete**, press **Enter**, and confirm **Yes**.

4.3 The Tracks page

If the Tracks page is in your page sequence, just press **Page** until the Tracks page appears. If not, press **Menu – Menu - Tracks** to access the Tracks page. Practice turning the active track log **On** and **Off** by

using the rocker key to highlight either the **On** or **Off** position, and then pressing the **Enter** key to activate the selected position.

Leave the active track log turned **On** for now.

1. The percent of active track log memory currently in use is displayed. For example, the active track log's memory is 10% full in Figure 1 below.

2. Selecting **Clear** and pressing **Enter** will clear (empty out) the active track log. The active track log cannot be deleted, but it can be cleared of all its content. See Figure 2 below.

3. Select **Setup** and press **Enter** to establish active track log settings. Figure 3 below illustrates common settings for an active track log.

What are the implications of checking **Wrap When Full**?

What is the difference between the **Time** and the **Distance** Record Method?

What should be considered when setting the time **Interval**?

What options do you have when you access **Data Card Setup**?

4.4 Saved tracks

1. If the active track log has content (> 0% active track log memory used), select **Save**, press **Enter**, and confirm **Yes** on the Tracks page, as in Figure 1 below.

2. The **Name**, **Color**, and **Show On Map** fields on the Saved Track page can be edited just like fields on the Waypoints page, see Figure 2 below. Why might that be a handy feature?

How could you change the displayed units for **Distance**, or for **Area**?

Is the saved track an exact copy of the active track log's content?

Does saving an active track log clear the active track log's content?

Press **Delete** and confirm **Yes** to delete the saved track.

4.5 Clear the receiver's active track log, delete all saved tracks, and delete all waypoints

Downloading tracks or waypoints from the receiver does not clear or delete them from the receiver. This permits users to download tracks and waypoint as often as they are needed. Since they are no longer needed, practice clearing the active track log and deleting all waypoints.

1. Browse to the Tracks page to confirm that the receiver's active track log is turned off. If it isn't, use the rocker key to select the active track log's **Off** position, and press **Enter**.

2. Clear the active track log by pressing **Clear** and confirming **Yes** from the Tracks page.

3. Delete all saved tracks by pressing **Menu – Delete All Saved** and confirming **Yes** on the Tracks page.

4. Delete all receiver waypoints by pressing **Find – Waypoints – Menu – Delete… - All Symbols**, and confirming **Yes**.

4.6 Field exercise: Navigation

Make sure you have deleted all waypoints from your receiver before beginning this exercise.

Navigation Exercise:

The incident is getting more complex and additional helispots are needed for operations.

You will play two characters in this scenario, a field observer (FOBS) and the operations section chief (OSC2). As a FOBS, you have been asked to collect the location for a potential helispot and mark it. You must return to ICP to communicate those coordinates to the OSC2, both verbally and in written format.

As OSC2, you need to check the suitability of a potential helispot mapped by a FOBS. You will receive those coordinates from him or her and navigate there.

FOBS

Objectives:

Collect waypoint, record coordinates, communicate coordinates.

Tasks:

1. Collect waypoint at potential helispot location. Mark location.
2. Record coordinates on worksheet in **Degrees, Minutes, Seconds** and note **datum**.
3. Return to ICP. Verbalize coordinates properly to partner and have them write them down. Write coordinates properly on white board and confirm how your partner wrote it matches.

Coordinates of helispot waypoint you created:

Latitude_____

Longitude_____

Datum_____

OSC2

Objectives:

Enter coordinates in receiver, navigate to location

Tasks:

1. Get someone else's helispot coordinates verbally and record below (in proper format).
2. Set up receiver to correct position format and datum before entering coordinates.
3. Navigate to helispot. Retrieve marker and bring to ICP.

Coordinates of helispot you received from FOBS:

Latitude_____

Longitude_____

Datum_____

4.7 Coordinate Conversion

Latitude Longitude Coordinate System

A circle contains 360 degrees
One degree contains 60 minutes
One minute contains 60 seconds

Degrees, minutes, seconds are the values used by dispatch
Example: fire cache is about 40° 21' 49"N, 105° 33' 34"W and would be read as:
40 degrees 21 minutes 49 seconds north (north of the equator)
105 degrees 33 minutes 34 seconds west (west of the prime meridian (London))

Degrees, decimal minutes are normally for aviation
Example: 40° 21.8' N, 105° 33.6' W
40 degrees 21.8 minutes north
105 degrees 33.6 minutes west

GIS specialist, GPS output used **decimal degrees**.
Example: 40.3636° N, 105.5594° W

We can manually convert among degrees minutes seconds, degrees and decimal minutes and decimal degrees:
To convert from degrees minutes and seconds to degrees and decimal minutes

- Divide the number of seconds by 60 and add that value to the number of minutes – do not change the number of whole degrees
- Example
  - To convert 40º 05' 18" N to degrees and decimal minutes do the following
    - We are converting the seconds to a decimal part of a minute
    - Divide the seconds (18) by the number of seconds in a minute (60) this will give the decimal part of a minute that 18 seconds represents
    - 18/60 = 0.3
    - Add the decimal minutes to the minutes and "discard" the seconds
    - 05 + 0.3 = 5.3
    - So the answer is 40º 05.3' N

To convert from degrees and decimal minutes to decimal degrees

- Divide the number of minutes by 60 and add that value to the number of degrees – do not change the number of whole degrees
- Example
  - To convert 40º 05.3' N to decimal degrees do the following
    - We are converting the minutes to a decimal part of a degree
    - Divide the minutes (5.3) by the number of minutes in a degree (60) this will give the decimal part of a degree that 5.3 minutes represents
    - 5.3/60 = 0.08833
    - Add the decimal degrees to the degrees and discard the minutes
    - 40 + 0.08833 = 40.08833
    - So the answer is 40.08833º

Manual Calculations:
1.) Dispatch just told you a smoke was reported at:
N 44º 03’ 24” latitude & W 121º18’ 48” longitude (NAD83).

You need to send a helicopter to check it out. What are the coordinates in degrees, decimal minutes?

N _____º_____’

W _____º _____’

2.) The helicopter told you the location of your proposed fuel treatment over the radio as:
N 36º 12.0’ latitude & W 80º 30.0’ longitude (WGS84).

You need to enter the coordinates into NFPORS as decimal degrees. What are they?

N _____._____º

W _____._____º

3.) The helicopter told you the location of a new smoke over the radio as:
N 36º 25.5’ latitude & W 80º 20.9’ longitude (WGS84).

You need to report to dispatch. What are the coordinates in degrees, minutes, seconds?

N _____º_____’ _____”

W _____º _____’ _____”

Using your GPS:

The GIS specialist gave you the location of a water source as:
Zone 16 0429767 Easting & 4932311 Northing (NAD83).

You need to give the coordinates to someone in the field who is using an old USGS map. What are the coordinates in degrees, minutes, seconds NAD27?

N _____º_____’ _____”

W _____º _____’ _____”

4.8 Field exercise: Data Collection – Restoration Fire

Clear the active track log, delete all saved tracks, and delete all waypoints before beginning this exercise.

Restoration Fire Scenario Mission Briefing:
You are assigned as a fire effects monitor on the "Restoration Complex," a series of fires burning in the wilderness area of Perfect Plants National Park.

Task #1:
The operations section chief needs the locations of 4 archeological sites that are in the proposed Maximum Manageable Area (MMA). Collect those 4 waypoints with as much accuracy as possible.

Task #2:
Please collect the perimeter of the Restoration Fire, which went out two days ago. The situation unit would like the acres of the fire as well.

Task #3:
When you return to camp the GISS will download both the arch sites and the fire perimeter data for the situation unit leader.

- The base GIS data at the park is in **UTM Zone ___, NAD83 datum**.
- Data will also be saved a as a **text files (.txt).**

Questions:

1.) How will you collect the locations of the arch sites?
a.) waypoints
b.) averaged waypoints
c.) track

2.) How will you collect the fire perimeter?
a.) waypoints
b.) averaged waypoints
c.) track

3.) How will you set up your receiver to collect the perimeter?
Record method _____
Interval___

4.) How many acres is the Restoration fire? _____

5.) What perimeter (active track or saved track) would you give to the GISS? _____
why?_____

4.9 Field exercise: Data Collection – RxWUI Fire

Clear the active track log, delete all saved tracks, and delete all waypoints before beginning this exercise

RxWUI Fire Scenario Mission Briefing:

This morning, a prescribed fire (RxWUI) was used to reduce hazard fuels in the wildland-urban interface of Sprawlsurrounded National Wildlife Refuge.

The burn boss has asked you (FFT2) to collect some data for him using GPS while the rest of the crew is mopping up.

- Collect the burn perimeter
- Collect two small spot fires that were suppressed, to ensure they are checked closely during mop-up.

He would like some additional data to add to the refuge GIS data sets, to hopefully use for future planning for that burn unit and fire management unit.

- The burn plan identified three contingency lines for management triggers. He would like you to collect where those were located.
- Two porta-tanks were pre-positioned before the burn and he wants to remember where, so he needs waypoints for the locations.

He would like all data delivered to him as shapefiles in **UTM Zone ___, NAD83** datum for future use with other refuge GIS data.

Questions:

1.) What features are you being asked to collect? (list below)

a.) waypoints

_____, _____, _____, _____

b.) track

_____, _____, _____, _____

2.) Which track will you collect first? _____ why? _____

3.) How will you keep track of all the waypoints you need to collect? _____

_____

4.10 Open DNRGarmin

1. Connect your Garmin GPS receiver to a PC using a serial or USB cable, and turn the GPS receiver on.

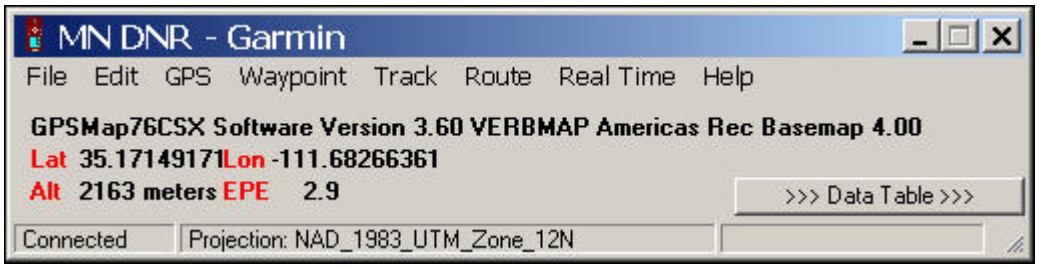
2. To open DNRGarmin from ArcMap:

   a. Open ArcMap and activate the DNR Garmin Toolbar (right) by clicking **View – Toolbars – DNR Garmin Toolbar**.

   b. Click **Open DNRGarmin** on the DNR Garmin Toolbar to open the DNRGarmin application.

3. **Don't perform this step. It is for information only**. To open DNRGarmin as a stand-alone application, click **Start – All Programs – DNRGarmin – DNRGarmin** from the Windows desktop, or double-click the DNRGarmin desktop icon, right.

Once opened, the DNRGarmin application should look like this. All exercises in this class will assume that DNRGarmin is being used in conjunction with ArcMap.



4.11 Check connection to DNRGarmin

DNRGarmin's status bar should indicate "Connected", as above. If it doesn't, check these items:

1. Click **GPS – Set Port**. Typical port choices include **USB** (a USB port) or **Port 1** (a serial port).

2. Click **GPS – Set Baud Rate**. Garmin's default baud rate is **9600**.

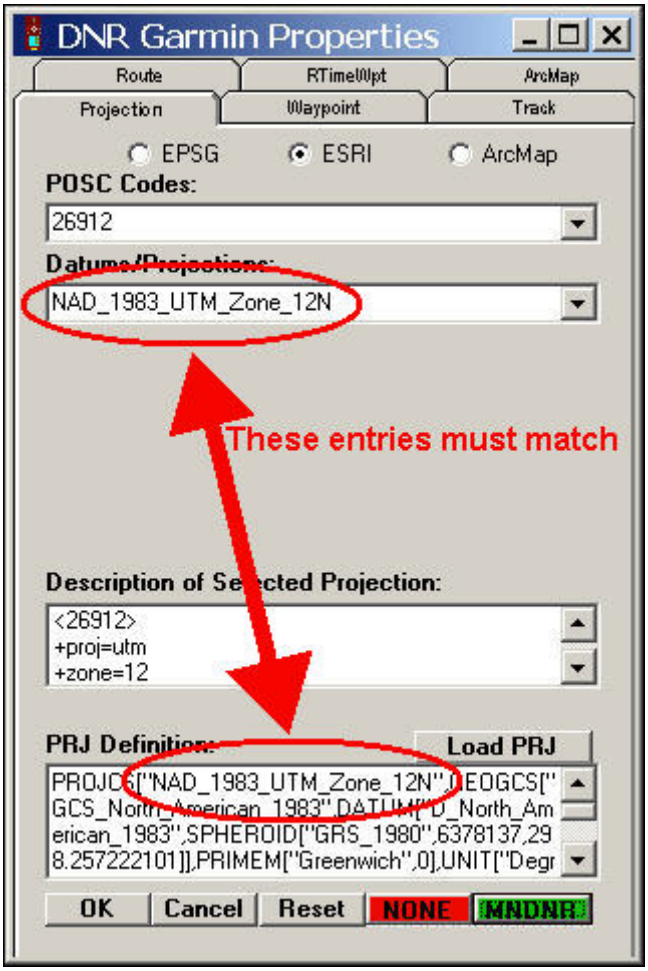
3. If using a serial connection, confirm that the receiver's protocol (on the receiver's Interface Setup page) is set to **Garmin**, and not to **NMEA**.

4. Try to determine if the Garmin USB driver was installed successfully.

4.12 Set DNRGarmin's projection to match that of the source or target GIS

Setting DNRGarmin's projection insures that WGS84 latitude and longitude from the GPS receiver are correctly exported (transformed and projected) into a coordinate format that matches your target GIS. The same process occurs in reverse when GIS features are imported into DNRGarmin for subsequent upload to a GPS receiver.

1. Click **File – Set Projection**.
2. Click the **ESRI** radio button.
3. Select the desired projection from the **Datums/Projections:** dropdown list.
4. Click **Load PRJ**, browse to **Projected Coordinate Systems – UTM – NAD 1983**, and select the corresponding projection (.prj) file.
5. Make sure that the **Datums/Projections:** and **PRJ Definitions:** entries match, as illustrated at right.
6. Click **OK**.



4.13 Download track log segments from the Data Collection Field Exercise

1. Click **Track – Download**.
2. When transfer is complete, answer these questions.
   a. Are all records identified as "**ACTIVE LOG**"? Why or why not?
   b. What is represented in the **lat**, **long**, **y_proj**, and **x_proj** fields?
   c. What is represented in the **new_seg** field?
   d. What is represented in the **time** field and the **ltime** field?
   e. What could you do if values in the **ltime** field weren't correct?

4.14 Convert track log segments representing linear features into a shapefile

1. Select all track segments representing the line features (contingency lines).
   a. **Click** the first record and **Shift – Click** the last record of a track segment to select all its records. Hint: The first record of each track log segment is tinted blue, and has the value "True" in its **new_seg** field.

2. Click **File – Save To – ArcMap – Shapefile Layer…**. Be sure to select **ArcView projected shapefile** as the **Save as type**.
3. Browse to an **appropriate** folder, and name the shapefile with a logical name.
4. Define the output shape type as **Line**, and click **OK**.
5. View the result in ArcMap. Were the results what you expected? If features aren't visible, right-click the layer in ArcMap's Table of Contents, and select **Zoom To Layer**.
6. To add a background photo to ArcMap, click the **Add Data** button and browse to **..instructor will provide data path**

4.15 Convert track log segments representing polygon features into a shapefile

1. Select all track segments representing the polygon feature (fire perimeter).
   a. **Click** the first record and **Shift – Click** the last record of a track segment to select all its records. Hint: The first record of each track log segment is tinted blue, and has the value "True" in its **new_seg** field.

2. Click **File – Save To – ArcMap – Shapefile Layer…**. Be sure to select **ArcView projected shapefile** as the **Save as type**.
3. Browse to an appropriate folder, and name the shapefile **a logical name**.
4. Define the output shape type as **Polygon**, and click **OK**.
5. View the result in ArcMap. Were the results what you expected?

4.16 Download waypoints from Data Collection Field Exercise

1. Click **Waypoint – Download**

2. Do you see waypoints representing point features from the field exercise?

4.17 Convert waypoints into a shapefile

1. Click **File – Save To – ArcMap – Shapefile Layer…**. Be sure to select **ArcView projected shapefile** as the **Save as type**.

2. Browse to an appropriate folder, and name the shapefile **a logical name**.

3. View the result in ArcMap. Were the results what you expected?

4.18 Field exercise: Data Collection – Oops Fire

Clear the active track log, delete all saved tracks, and delete all waypoints before beginning this exercise

Oops Fire Scenario Mission Briefing:

The Oops Fire is a Type I incident in Smokey Bear National Forest. The fire was 90% contained yesterday. This forest experiences a lot of fire activity. The forest supervisor has asked the Incident Command Team to provide him with the incident GIS data at closeout so it can be added to the forest data library for use with future fires. The team was not able to get their order filled for a GISS until today so no GIS data has been created yet. You are a field observer, and since fire activity and fire behavior have decreased, you have been asked to help collect GPS data for the new GISS at the ICP.

Although the Situation Unit Leader uses GPS often, he doesn't fully understand GIS so his directions on how to collect the data aren't specific. He simply tells you he needs the following data:

- Fire perimeter (1)
- Spot Fire (1)
- Division Breaks (3)
- Dozer Line (1)
- Spike Camp (1)
- Dip Sites (3)
- Burned over hand line (1)
- Safety Zone (1)
- Escape Route (1)
- Helibase (1)
- Helispots (1)

You know that the first question you will be asked after your mapping mission is the acreage of the fire so you decide to save your fire perimeter track segment. You also know that communication on a fire is everyone's responsibility, so you contacted the GISS to find out what format he would like the data in. He said that he wants all data delivered to him as UTM, Zone ___, NAD83 datum. Data should also be saved a as a **text files (.txt).**

Questions:

1.) Will you average any of your waypoints? If yes, which one(s)? _____

2.) Which track will you collect first? _____ why? _____

3.) How will you keep track of all the waypoints and track features you need to collect?
_____

4.) What would be a good name for the hand line shapefile?
_____

5.) Will you save any track segments? _____

6.) How big is the Oops fire? _____

4.19 Upload a polygon shapefile to the receiver's active track log

In addition to converting track segments into GIS line and polygon features, DNRGarmin also facilitates the reverse process of converting existing GIS line and polygon features into active track log segments.

1. In ArcMap, click the **Add Data** button and browse to the **wilderness boundary** shapefile. (instructor will provide data directory path)

2. Click once on the shapefile name in ArcMap's Table of Contents to select it.

3. In DNRGarmin, click **File – Load From – ArcMap – Layer** to import the GIS polygon's vertices into DNRGarmin's table. Most receivers can accommodate up to 10,000 track points.

4. In DNRGarmin, click **Track – Upload** to upload the GIS polygon's outline to the active track log. Browse to the receiver's Map page to view the polygon's outline.

4.20 Upload a point shapefile to the receiver's waypoint library

In addition to converting waypoints into GIS point features, DNRGarmin also facilitates the reverse process of converting existing GIS point features into waypoints.

1. In ArcMap, click the **Add Data** button and browse to the **lookout** shapefile. (instructor will provide data directory path)

2. Click once on the shapefile in ArcMap's Table of Contents to select it.

3. In DNRGarmin, click **File – Load From – ArcMap – Layer** to import the GIS points into DNRGarmin's table. Most receivers can accommodate up to 1,000 waypoints.

4. Populate DNRGarmin's **ident** field with the shapefile's **point_num** field.

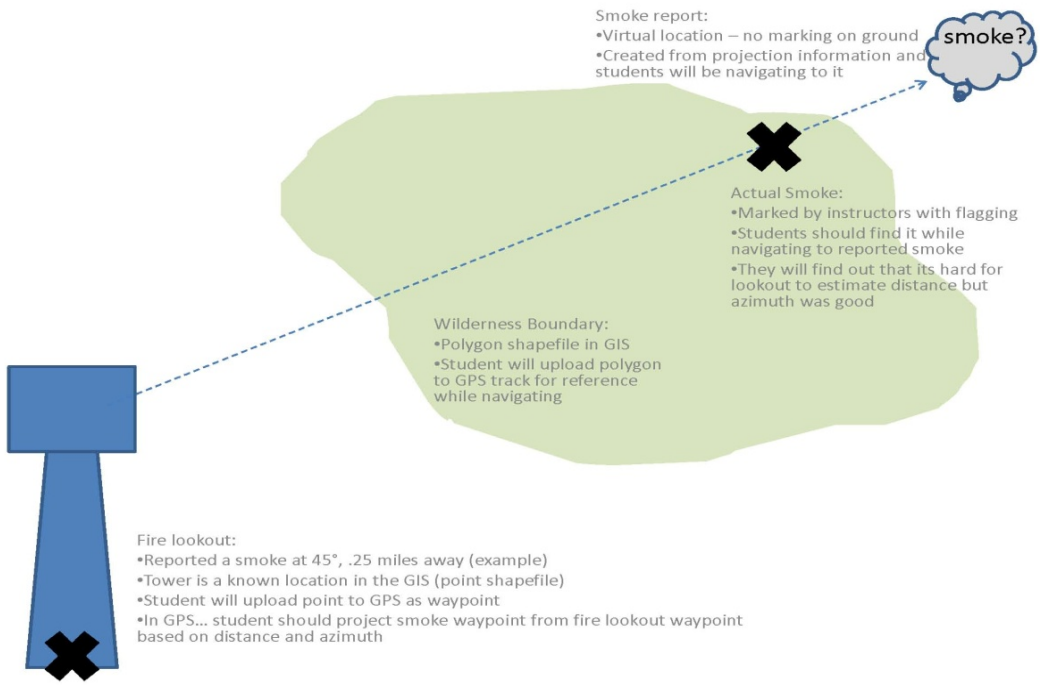
5. Double-click the **symbol** field header, and select the **City (Medium)** symbol.

6. In DNRGarmin, click **Waypoint – Upload** to upload the GIS points to the receiver's waypoint library. Browse to the receiver's Map page to view the new waypoints.

   New waypoints will over-write existing waypoints if they have the same name.

7. You are ready for the next field exercise.

4.21 Field exercise: Smoke Chasing



You are a smoke chaser.
The fire lookout tower just called in a smoke at _____º and _____ miles from fire tower.
You are asked to go check it out, and give dispatch the actual coordinates. They also need to know whether or not the fire is in the wilderness. You know the location of the fire tower and the wilderness boundary are both in the GIS data library, so you will use those data to help you with this mission.

_____

Objectives:

Create a new waypoint from the tower using the distance and azimuth given. Navigate to the smoke and determine whether the fire is in the wilderness.

Tasks:

1. Upload the fire tower point and wilderness boundary polygon into the GPS receiver.
2. Project smoke location from fire tower waypoint using distance and bearing from tower.
3. Navigate to smoke location
4. Record actual location with a new waypoint
5. Determine if fire is in the wilderness

Is the fire in the Wilderness? _____

Discussion:
In your job, can you think of situations where you may want or need to project a waypoint?
What other GIS data layers would you find helpful to upload to your GPS unit and why?

Advanced/Optional Exercises:

4.22 Create a polygon feature from waypoints

Waypoints can be converted into track points, a series of track points are equivalent to a track segment, and a track segment can be converted into a polygon (or line) GIS feature. Delete all waypoints and saved tracks and clear your active log. Go outside and collect 5-7 waypoints around an area feature – real or imaginary (i.e. walk around in a circle or other shape). Also collect a meandering track in between two of the points.

1. Download GPS waypoints.

2. Click the **Track** radio button, and notice that each waypoint record has been converted to a track record.

3. Click **File – Save To – ArcMap – Shapefile Layer…**. Be sure to select **ArcView projected shapefile** and specify the shape type as **Polygon.**

4. View the result in ArcMap. Were the results what you expected?

4.23 Create a polygon feature from a combination of a track segment and waypoints

In this exercise, you'll create a polygon GIS feature from a combination of waypoints and the meandering track segment.

1. Make each Track field visible by clicking **Track – Track Properties…**, and placing a check mark in each box.

2. Download GPS waypoints.

3. Click the **Track** radio button to convert the waypoints to track points.

4. Select the ordered track points using the **Click** and **Shift – Click** method, and **Copy** them to DNRGarmin's clipboard .

5. Download GPS track logs.

6. Add empty track records to the end of DNRGarmin's table by clicking the **Add Record** button , once for each of the clipboard's track points.

7. Click in the far left cell of the first added (empty) record, and click **Paste** .

8. Change the first added record's **new_seg** value from **True** to **False**.

5. Click **File – Save To – ArcMap – Shapefile Layer…**. Be sure to select **ArcView projected shapefile** and specify the shape type as **Polygon.**

9. View the result in ArcMap. Were the results what you expected?

4.24 Shorten the list of Datums/Projections: choices (optional)

Users can reduce the very long list of choices in DNRGarmin's **Datums/Projections:** dropdown list to those most frequently used. If interested in doing so, refer to section 3.13 of the class notes, and follow the procedure described there.